CANADIAN NATIONAL RAILWAYS

STANDARD SPECIFICATIONS
FOR
STEEL RAILWAY BRIDGES
(FIXED SPANS)

1922

TORONTO, ONT.
MAY 1, 1922

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This Specification (with the exception of paragraphs bearing affixed numbers) is in substantial agreement with the Canadian Engineering Standards Association Standard Specification for Steel Railway Bridges dated April, 1922.

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APPENDICES

CANADIAN NATIONAL RAILWAYS

GENERAL SPECIFICATIONS

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Introductory

Scope

1. This Specification is intended to apply to Fixed Spans 300 feet or under.

Definitions

2A. The term "Railway Company" refers to the Canadian National Railways or any of its subsidiary branches or leased lines.

3A. The term "Engineer" refers to the Chief Engineer of the Railway Company or his duly authorized agents.

4A. The term "Inspector" refers to the Inspector or Inspectors representing the Railway Company.

6A. The term "Contractor" refers to the manufacturing, fabricating, or erecting Contractor.

Highway Traffic

7. When highway traffic is to be accommodated, the additional loading shall be as specified by the Engineer.

Tenders and Proposals

8A. All tenders and proposals are to be submitted in duplicate on the forms supplied by the Railway Company for this purpose. Tenders are to be based on plans and specifications as furnished by the Railway Company and unless otherwise called for, the Contractor is not required to submit any stress sheets or other drawings with his tender.

Drawings to Govern

9A. Where the Railway Company's drawings and the specifications differ, the drawings shall govern.

Correctness of Drawings

10. The Contractor shall be responsible for the correctness of all his drawings, irrespective of any approval by the Engineer.

11. Any material ordered prior to the approval of the drawings shall be at the Contractor's risk.

Patented Devices

12A. The Contractor shall, unless otherwise specified, protect the Railway Company against all costs and claims on account of patented devices or parts used by him in the Bridge.

Drawings

12B. After the contract has been awarded and before any materials are ordered the Contractor shall submit to the Engineer for approval duplicate blue prints of all stress sheets, and before any shop work is commenced he shall submit duplicate blue prints of shop details and erection diagrams and other drawings made by him. The Contractor is not to make any alterations to any approved drawing without the authority of the Engineer. After approval the Contractor is to furnish the Railway Company with such additional prints of each drawing as may be required (usually four sets). On the completion of the Contract, the original tracings become the property of, and are to be delivered to the Railway Company.

12C. Drawings are to be made on the Railway Company's standard size sheets as shown in Appendix I. Ordinarily, drawing size "B" is to be used but in any case all drawings made for any one bridge are to be on the same size sheet.

Freight Rates, Duties and Taxes

12D. Any amounts paid by the Contractor in connection with work being done under this contract, for freight, duties or Dominion Government Taxes due to increases

in any of these after tenders have been submitted, will be paid to the Contractor by the Railway Company and vice versa any decreases in payments for any of these items are to be allowed the Railway Company by the Contractor.

General Features

Types of Spans

13. Different types of Spans will be referred to by descriptions and abbreviations as shown in Appendix II.

Materials Used

14. The Bridge shall be constructed wholly of "Structural Steel for Bridges," except in pier members or where otherwise specified. All materials shall be in accordance with the Specifications given in the Appendices relating thereto.

Clearance

15. Single track through bridges on tangent track shall have a clear opening not less than that shown in Appendix III. Where track alignment is curved, additional lateral clearance shall be provided to give the same minimum clearance for a car 85 feet long, 14 feet high (above base of rail) and 60 feet centre to centre of trucks, allowance being made for curvature and superelevation in track.

16. For through bridges carrying two or more tracks on any span, the lateral clearance between the centre line of track and the adjacent truss or girder shall be as specified above for single track bridges.

17A. The distance centre to centre of tracks where there is more than one track, and also the amount of superelevation on the outer rail on curved track, shall be as shown on the Railway Company's drawings.

Deck Spans on Curves

17B. Deck Spans on curves shall be set so that at the centre of span the centre line of track is to one side of the centre line of span, one-third of the middle ordinate and at either end of span the centre line of track is to the other side of the centre line of span, two-thirds of the middle ordinate. Deck plate girder spans on curves shall usually be tilted the required amount to take up the full amount of the superelevation in the track.

Spacing of Trusses or Girders

18. The distance, centre to centre of trusses or main girders, shall be not less than 1/15 of the effective span, and not less than is necessary to prevent overturning under the specified lateral forces.

Skew Ends

19. At the abutment ends of all skew spans the ends of track stringers or girders carrying deck ties shall be square to the track unless a continuous ballasted deck is to be used.

Decks

Type of Deck

20A. The type of deck shall be as shown on the Railway Company's drawings.

Timber Decks

21A. Deck ties, preferably not less than 13 feet long, shall be proportioned to carry the maximum axle load specified with full impact, distributed over 3 feet of track.

21B. Details of tie spacing, tie dapping, guard timbers, guard rails, and deck fastenings, shall be in accordance with the Railway Company's Standard Drawings.

22. Timber unless otherwise specified shall be Douglas fir, White, Red, or Southern long-leaf pine, and shall be of the grade known as "Merchantable."

Solid Decks

23. Transverse beams for supporting ballasted decks shall be proportioned for the maximum axle load with full impact, distributed longitudinally over 3 feet, or a distance equal to twice the depth from base of rail to top of transverse beams, whichever dimension is the greater, and distributed transversely over 10 feet.

Floor Iron

24. Unless otherwise specified by the Engineer, hook bolts, guard timber bolts and other floor iron shall be supplied by the Contractor and will be paid for at the same rate as for steel in the structure.

Loads and Stresses

Dimensions for Calculations

25. The dimensions for calculation of stresses shall be as follows:—

Span Lengths—

For *trusses and girders*, the distance centre to centre of end bearings.
For *floor beams*, the distance centre to centre of trusses or girders.
For *stringers*, the distance centre to centre of floor beams.

Depths—

For *riveted trusses*, the distance between centres of gravity of chord sections.
For *pin connected trusses*, the distance centre to centre of chord pins.
For *plate girders, floor beams and stringers*, the distance between centres of gravity of flanges, but shall not exceed the distance back to back of flange angles.

Loads

26. The structure shall be proportioned for the following loads:—

(*a*) Dead load.
(*b*) Live load.
(*c*) Impact or dynamic effect of live load.
(*d*) Lateral force, without impact.
(*e*) Centrifugal force, without impact.
(*f*) Longitudinal force, without impact.
(*g*) Temperature stresses.

Stresses due to each of the above loads and forces shall be shown separately on the stress sheet.

Dead Load

27. The dead load shall consist of the weight of the entire supported structure, computed in accordance with the following unit weights:—

Steel	490 lbs. per cu. ft.
Concrete	150 " " "
Sand and Gravel (ballast)	120 " " "
Asphalt mastic	150 " " "
Paving brick	150 " " "
Oak, birch or maple	5 lbs. per ft. B.M.
Creosoted pine or fir	5 " " " "
All other soft woods	4 " " " "
Rails and fastenings	150 lbs. per lin. ft. per track

Live Load

28. The live load for each track shall consist of two typical engines followed by a uniform train load, or of the alternative loading on two axles 7 feet apart, both as shown in Appendix IV; and that producing the greater stress shall be used. The class of live load shall be as specified by the Engineer.

Eccentricity

29. In designing either deck or through bridges provision shall be made for the increased load carried by any member due to the eccentricity of the load, arising from curved track or other cause. Stringers shall follow the curvature of the track as nearly as practicable.

Impact

30A. Impact shall be computed by the formula—

$$I = \frac{L^2}{L+D}$$

in which I = Impact stress.
L = computed maximum live load stress.
D = computed dead load stress which in combination with live load stress and impact gives the maximum total stress (See Par. No. 41).

Lateral Forces

31. The lateral (or wind) force shall consist of a moving load equal to 30 pounds per square foot on 1½ times the area of the structure projected on a vertical plane parallel to the longitudinal axis (but not less than 200 pounds per lineal foot at the loaded chord and 150 pounds per lineal foot at the unloaded chord), and a moving load of 600 pounds per lineal foot applied 8 feet above base of rail.

32. If greater stresses are provided by a moving load of 50 pounds per square foot acting on 1½ times the area of the unloaded structure projected on a vertical plane parallel to the longitudinal axis, such stresses shall be provided for.

33. For Viaduct Towers, the lateral forces to be considered shall be as above, but provision shall be made for a horizontal force on the towers of not less than 225 pounds per lineal foot of height on each bent from top of pedestal to under side of girder for the structure when loaded, and 375 pounds per lineal foot of height for the structure unloaded. In calculating the uplift the viaduct shall be considered as loaded on any one track with empty cars assumed to weigh 1200 pounds per lineal foot, if this loading gives a greater result than that specified above for the unloaded condition.

Centrifugal Forces

34. On curves, the centrifugal force (assumed to act 6 feet above base of rail) shall be taken as equal to a percentage of the live load, according to the following table:—

Degree of Curve	20′	40′	1°	2°	3°	4°	5°	6°	7°	8°	9°	10°	11°	12°
Percentage	2½	5	7½	10	10	10	10	10	10	10	10	10	10	10
Speed, Miles per hour	80	80	80	65	53	46	41	38	35	33	31	29	28	27

Longitudinal Force

35. The longitudinal force produced either by the traction of the engines, or by the application of the brakes when applied to a moving train, shall be assumed to act 6 feet above the base of rail. For loaded lengths up to 400 feet this longitudinal force shall be computed by the formula:—

$$T = \tfrac{3}{4}(4 - L)^2 + 10$$

in which T = longitudinal force, in percentage of the live load.
L = loaded length, in units of 100 feet.

36. For loaded lengths of 400 feet and over the longitudinal force shall be assumed equal to 10 per cent. of the live load.

Temperature Stresses

37. Provision shall be made for temperature stresses due to an extreme variation of 160 degrees Fahrenheit, with a normal temperature of 60 degrees, and a range from 40 degrees below zero to 120 degrees above.

Combined Stresses

38. In proportioning the various parts of the structure, provision shall be made for each of the following groups of stresses:—

Group A—Dead load,
Live load,
Impact,
Centrifugal force,
at the Unit Stresses herein specified.

Group B—Lateral force,
Longitudinal force,
Temperature stress,
jointly or separately, at the Unit Stresses herein specified.

Group C—Any one or more of Group A combined with any one or more of Group B, at Unit Stresses 25 per cent. greater than those hereinafter specified.

Reversal of Stress

39. Members in which the static live load stress may have two maximum values, one of similar sign to the dead load stress, and one of opposite sign, shall be proportioned for either—

(*a*) The full dead load stress combined with the maximum live load stress of the same sign with its corresponding impact,

(*b*) The maximum live load stress of the opposite sign with its corresponding impact, less two-thirds of the dead load stress,

each combination being further increased by an amount equal to one-half the smaller of the two combinations.

40. Where the live load stress is always of opposite sign to the dead load stress only combination (*b*) will apply, and no further increase shall be made.

Provision for Heavy Decks

41. Where a bridge is designed for a future heavy deck, but a lighter deck is to be used temporarily, that dead load stress shall be used which in combination with the live load stress will require the maximum section.

Axial and Bending Stresses Combined

42. Members subject to both axial and bending stresses shall be proportioned so that the combined fibre stress will not exceed the allowed axial Unit Stress; except such members as may be subject to bending moments from their own weight, when the total fibre stress shall not exceed the allowed axial Unit Stress by more than 10 per cent.; but in no case shall the section be less than that required for the axial stresses alone.

43. For members continuous over panel points and subject to transverse loading, the bending moments, both at the panel points and at the centre, shall be taken as three-fourths of those computed as for a simple beam of span equal to one panel length.

Secondary Stresses

44. Designing and detailing shall be carried out so as to minimize secondary stresses. In ordinary trusses without sub-panelling, no account usually need be taken of the secondary stresses in any member whose width measured in the plane of the truss is less than one-tenth of its length. Where this ratio is exceeded, or where sub-panelling is used, secondary stresses due to deflection of the truss shall be computed. The allowable Unit Stresses specified may be increased one-third for a combination of the secondary stresses with the axial stresses.

Unit Stresses

45. The several parts of the structure shall be so proportioned that the Unit Stresses will not exceed the following, except as modified elsewhere in this Specification. Unless otherwise noted, the Unit Stresses herewith are for "Structural Steel for Bridges", and are given in pounds per square inch.

Tension

46. Axial tension on net section 16 000

Compression

47. Axial compression on gross section of columns ..... $15\,000 - 50\left(\frac{l}{r}\right)$
but not greater than 12 500
in which—
l = the unsupported length, centre to centre of intersections.
r = the least radius of gyration applicable to this length.
Direct compression on steel castings 14 000
Direct compression on iron castings 10 000

Bending

48. Bending on extreme fibres of:

Rolled shapes, built-up sections and girders (net section)	16 000
Pins	24 000
Steel castings	12 000
Iron castings	3 000
White oak, Douglas fir and Southern long-leaf pine	1 800
White and red pine, and Spruce	1 200

Shearing

49. Shearing on:

Pins and power driven shop rivets	12 000
Power driven field rivets	10 000
Hand driven field rivets and turned bolts	8 000
Plate girder webs (gross section)	10 000

Bearing

50. Bearing on:

Pins, power driven shop rivets, outstanding legs of stiffener angles, and other steel parts in contact	24 000
Power driven field rivets	20 000
Hand driven field rivets and turned bolts	16 000
Hard bronze sliding expansion bearings	1 000
Expansion rollers, per lineal inch	$600d$
in which d = diameter of roller in inches.	
White oak—Perpendicular to grain	1 100
Across grain	500

Douglas fir and Southern long-leaf pine—Perpendicular to grain	1 000
Across grain	300
White and red pine and Spruce—Perpendicular to grain	700
Across grain	170
Granite masonry	800
Concrete	600
Limestone masonry	400
Sandstone masonry	400

51. The above mentioned values for shear and bearing shall be reduced 25 per cent. for countersunk and floor connection rivets.

52. The diagonal tension in webs of girders or rolled beams at sections where shear and bending occur simultaneously, shall not exceed 16 000 pounds per square inch.

Nickel Steel

53. When "Structural Nickel Steel" is used, the Unit Stresses for this material may be 40 per cent. in excess of those given above for "Structural Steel for Bridges."

Proportioning of Parts

Net Section at Rivet Holes

54. In proportioning riveted tension members, the diameter of the rivet holes shall be taken 1/8 inch larger than the nominal diameter of the rivet; and allowance shall be made in each component part of the member for as many rivet holes as it contains gauge lines, unless the distance centre to centre of rivet holes, measured on the diagonal, is at least 40 per cent. greater than the distance between the gauge lines.

Net Section at Pin Holes

55. In pin connected riveted tension members, the net section, both through the pin hole and at the back of same, shall exceed the net section of the body of the member by at least 25 per cent.

Limiting Lengths of Members

56. The ratio of length to least radius of gyration shall not exceed 100 for main compression members nor 120 for wind and sway bracing, but for built up I sections the radius of gyration may be computed for the flange materials alone, neglecting the web plate, in which case the latter shall not be counted on as effective section for axial compression.

57. The lengths of riveted tension members shall not exceed 200 times their least radius of gyration.

Open Sections

58. Structures shall be so designed that all parts will be accessible for inspection, cleaning and painting.

Water Pockets

59. Pockets or depressions shall be avoided as far as possible, and those which are unavoidable shall either be provided with effective drain holes, or they shall be filled with waterproof material, as directed by the Engineer.

Symmetrical Sections

60A. Main members shall be so designed that their neutral axes will be as nearly as practicable in the centres of their sections, and the neutral axes of all intersecting members shall meet in a common point.

Minimum Material

61. Metal shall not be less than 3/8 inch thick, except for fillers. Metal subject to marked corrosive influences shall be increased in thickness or protected against such influences, as specified by the Engineer.

62. No material used in compression shall have an unsupported width of more than 40 times its thickness.

Outstanding Flanges

63. The thickness of the outstanding leg of angles in compression, except when reinforced by plates, shall not be less than the following:—

(*a*) For girder flange angles, or for main members carrying axial stress, 1/12 the unsupported length of the outstanding leg.

(*b*) For bracing, stiffeners, and other secondary members, 1/16 the unsupported length of the outstanding leg.

Pony Truss Bridges

64. Pony truss bridges shall be of the riveted type, they shall have double webbed chords, and latticed or otherwise effectually stiffened web members.

65. In all pony truss bridges, the vertical truss members and the floor beam connections shall be proportioned to resist, in addition to the stresses already specified, a lateral force at the centre of gravity of the top chord of the truss not less than three per cent. of the maximum axial stress at that point.

Plate Girders

66. Plate girders shall be proportioned either by their moment of inertia, using the net section of both flanges and web, or by assuming that the flanges are concentrated at their centres of gravity. In the latter case, 1/8 of the gross section of the web, if properly spliced, may be used as flange section. For girders having unusual sections, the moment of inertia method shall be used.

Compression Flanges

67. The gross area of the compression flange of plate girders shall be not less than the gross area of the tension flange, and further, the stress per square inch shall not exceed:—

$$16\,000 - 200\frac{l}{b} \text{ pounds,}$$

in which—

l = the length of the unsupported flange, between lateral connections or knee braces, in inches.

b = the flange width, in inches.

68. Where flange cover plates are used, one cover plate on the top flange of through plate girders shall extend full length, and unless otherwise specified by the Engineer, all cover plates on the top flanges of deck plate girders shall extend full length (except where side cover plates are used in compound flanges). Other cover plates (including side covers in compound flanges) shall extend at least 18 inches beyond the theoretical point at each end.

Flange Sections

69. The flange angles shall form as large a part of the area of the flange as practicable. Side plates shall not be used except when flange angles exceeding one inch in thickness would otherwise be required.

70. Flange cover plates shall be equal in thickness, or shall diminish in thickness from the flange angles outward. No plate shall have a thickness greater than that of the flange angles.

71A. Splices in flange members of plate girders, when not shown on the Railway Company's drawings, shall not be used except by special permission of the Engineer. Two members in any one flange shall not be spliced at the same cross section, and, if practicable, splices shall be located at points where there is an excess of material. Flange angle splices shall consist of angles.

Web Plates

72. Web plates shall be so proportioned that the permissible shear on their gross section will not be exceeded. Splices in web plates shall be avoided as far as possible, but, when necessary, they shall be designed so that the full value of the web plate will be uniformly developed, both for bending and for shear.

Web Stiffeners

73. Plate girders shall have stiffener angles over end bearings, the outstanding legs of which shall extend as nearly as practicable to the outer edge of the flange angles. The end stiffeners shall be proportioned for bearing of the outstanding legs, which shall be arranged to transmit the end reaction to and distribute it over the pier members. They shall be connected to the web by enough rivets to transmit the reaction. End stiffeners shall not be crimped.

74. The webs of plate girders shall be stiffened by angles at intervals not greater than:—

(*a*) 6 feet.

(*b*) The depth of the web.

75. If the depth of the web between the flange angles or side plates is less than 60 times the thickness of the web, intermediate stiffeners may be omitted.

76. Intermediate stiffeners shall be riveted in pairs to the web of the girder. The outstanding leg of each angle shall not be less than 2 inches plus 1/30 of the depth of the girder.

77. Stiffener angles shall be placed at points of concentrated loading Such angles shall not be crimped.

Type of Truss and Sections of Members

77A. Trusses shall have single intersection web systems and preferably inclined end posts. The top chords and end posts shall be made usually of two side segments with one cover plate and with tie plates and latticing on the open side. The bottom chords of riveted trusses shall be symmetrically made, usually of vertical side plates with flange angles. Web members shall be made of symmetrical sections.

Spacing of Stringers

77B. Ordinarily there will be two lines of stringers for each track and these will be spaced 8 feet centre to centre. If four lines of stringers are used under one track, each pair will be spaced symmetrically about each rail.

Floor Beams

78. Floor Beams shall preferably be set at right angles to the trusses or main girders and they shall be rigidly connected thereto.

79. End floor beams shall be provided where possible and they shall be designed for jacking up the spans, under which condition the Unit Stresses herein specified shall not be exceeded by more than 50 per cent.

End Struts

80. When impossible to use end floor beams with through spans, end struts and stringer cross frames shall be provided, and these shall be rigidly connected to the stringers and to the trusses or main girders. Special provision shall be made for jacking up the span from the masonry bridge seats.

Design of Bracing

81. Lateral, longitudinal and sway bracing shall be composed of shapes with riveted connections. When a double system of bracing is used, both systems may be considered as simultaneously effective if the members meet the requirements both as to tension and compression.

82. The smallest angle to be used in bracing shall be 3½ x 3 x ⅜ inch. Angles shall be connected at their intersections by plates.

Lateral Bracing

83. Bottom lateral bracing shall be provided in all bridges, except deck plate girder spans less than 30 feet long, from which it may be omitted. Top lateral bracing shall be provided in all deck spans and all through truss spans.

84. Continuous steel or concrete floors will be considered as the equivalent of lateral bracing if the design and construction of such will fulfil the specified requirements.

85. Lateral bracing beneath timber decks shall be low enough to clear the ties by at least 1/2 inch.

Sway Bracing

86. Through truss bridges shall be provided with portal bracing, rigidly connected to the end posts and top chords; it shall be proportioned for total specified wind load on the top chords, and shall be as deep as the specified clearance will allow. Furthermore, sway bracing shall be provided at all intermediate principal verticals; or, in the case of trusses having no intermediate vertical members, on all principal compression diagonals. Sway bracing shall also be as deep as the specified clearance will allow.

87. Deck truss spans shall be provided with brace frames at each end proportioned to transfer the end reaction of the top lateral systems to the pier members. Deck truss spans shall have intermediate brace frames at all intermediate principal verticals, or in case there are no full depth intermediate verticals, on all principal compression diagonals.

88. Deck plate girder spans shall be provided with brace frames at each end proportioned to transfer the end reactions of the top lateral system to the pier members, and shall have intermediate brace frames at intervals not exceeding 15 feet.

Bracing of Stringers

89. Where two lines of stringers are used under each track, in panels more than 15 feet in length, they shall be subdivided into two or more panels and braced diagonally, and shall have a brace frame at each panel point.

Gusset Plates in Through Girders

90. In through plate girder spans, the top flanges shall be braced by means of gusset plates or knee braces with solid webs connected to the floor beams and extending usually to the clearance line. If the unsupported length of the inclined edge of the gusset plate exceeds 60 times its thickness, the gusset plate shall have one or two stiffening angles riveted along its edge. The gusset plate shall be riveted to a stiffener angle on the girder. Preferably it shall form no part of the floor beam web.

91. In through plate girder spans with solid floors, there shall be knee braces with ⅜ inch webs, extending usually to the clearance line at intervals of about 12 feet. Each knee brace shall be well riveted to the floor and the girder, especially at the top, and shall have its edge reinforced by one or two angles.

Proportioning Of Parts (Viaducts)

Rocker Bents

92. Where long spans are supported on short single bents, such bents shall have hinged ends, or else have their columns and anchorages proportioned to resist the bending stresses produced by changes in temperature.

Depth of Girders

93. Preferably all the girders in any one viaduct shall be of the same depth.

94. In double track viaducts the inner lines of girders shall be supported by transverse girders framed between and riveted to the posts.

Girder Connections and Bracing

95. Girders of tower spans shall be fastened at each end to the tops of the posts or transverse girders. Girders between towers shall have one end riveted, and shall be provided with an effective expansion joint at the other end. No bracing or brace frame shall be common to abutting spans.

96. If either of the girders under a track does not rest directly over a tower post bracing shall be provided to carry the longitudinal force into the tower bracing without producing lateral bending stress in the transverse girders or the posts.

Bottom Struts

97. The bottom struts of viaduct towers shall be proportioned for the calculated stresses, but in no case for less than one-fourth of the dead load reaction on one pedestal, considered as compressive stress. Provision shall be made in the column bearings for expansion of the tower bracing.

Shoe and Bed Plates

98. Shoe and bed plates shall be not less than 1¼ inches thick.

Anchorage for Towers

99. Anchor bolts for viaduct towers and similar structures shall be not less than 2 inches in diameter. They shall be designed to engage a mass of masonry the weight of which is at least one and one-half times the uplift.

Details Of Design

Packing of Eye Bars

100. The eye bars of a set shall be packed symmetrically about the plane of the truss as closely and as nearly parallel as practicable, and in no case shall the inclination of any bar to the plane of the truss exceed 1/16 inch per foot. They shall be held against lateral movement and arranged so that adjacent bars in the same panel will not be in contact.

Pin Plates

101. Pin plates shall be of sufficient thickness to provide the required bearing area upon the pin; they shall be as wide as the dimensions of the member will allow; and their length measured from pin centre to end, shall be at least equal to their width. Pin plates shall contain sufficient rivets to distribute their due proportion of the pin-pressure to the full cross section of the member; and only the rivets located in front of two lines drawn from the centre of the pin towards the body of the member and inclined at 45 degrees to the axis of the member shall be considered effective for this purpose. In the case of members composed of web plates and flange angles (with or without a cover plate) there shall be at least one outside pin plate covering the vertical legs of the flange angles.

Forked Ends

102. Forked ends on compression members will be permitted only when unavoidable; and, when used, a sufficiency of pin plates shall be provided to make the jaws of at least twice the sectional area of the member. On box sections at least one of these pin plates shall extend to the far edge of the farthest tie plate, and the remainder shall extend to the far edge of the nearest tie plate, and not less than 6 inches beyond the near edge of the farthest tie plate.

Pins

103. Pins shall be long enough to insure a full bearing thereon of all the parts connected thereby; they shall be secured, either by chambered nuts or by solid nuts provided with washers; and their screw ends shall be long enough to permit of burring the threads.

Filling Rings

104. Filling rings shall be provided, where necessary to prevent lateral movement on the pins of the members connected thereby.

Diameter of Rivets

105. In calculating the number of rivets required the nominal diameter only, or the size of the cold rivet before driving, shall be taken as effective.

105A. Rivets shall be of sizes shown on the Railway Company's drawings or specifications.

Pitch of Rivets

106. The minimum distance between centres of rivet holes shall be 3 diameters of the rivet, but the distance preferably shall be not less than:—

3½	inches	for	1	inch	rivets
3	"	"	⅞	"	"
2½	"	"	¾	"	"
2¼	"	"	⅝	"	"

The maximum pitch in the line of stress for members composed of plates and shapes shall be:—

7	inches	for	1	inch	rivets
6	"	"	⅞	"	"
5	"	"	¾	"	"
4	"	"	⅝	"	"

For angles with two gauge lines and rivets staggered, the maximum pitch in each line shall be twice the amount given above. If two or more web plates are used in contact, stitch rivets shall be provided to make them act as one. In compression members, the stitch rivets shall be spaced not more than 24 times the thickness of the thinnest plate in the direction perpendicular to the line of stress, and not more than 12 times the thickness of the thinnest plate in the line of stress. In tension members, the stitch rivets shall not be more than 24 times the thickness of the thinnest outer plate in either direction. In tension members composed of two angles in contact, a pitch of 12 inches may be used for riveting the angles together.

Rivets at Ends of Compression Members

107. In the ends of built compression members the pitch of rivets connecting the component parts of the member shall not exceed 4 times the diameter of the rivet for a length equal to 1½ times the maximum width of the member; except in angles having 2 lines of rivets staggered, where the pitch on each line may be twice this limit but not greater than that allowed for the body of the member.

Flange Rivets

108. The number of rivets connecting the flange angles of plate girders to the web plate shall be sufficient to develop the increment of flange stress transmitted to the flange angles, combined with any load (including impact) which may be applied directly thereto. Where the cross ties or sleepers rest upon the flange, the maximum wheel load shall be assumed to be distributed uniformly over a length of 3 feet. The maximum pitch in the vertical legs of the loaded flange angles shall not exceed 4 inches on a single line, or 8 inches where there are 2 lines of rivets, staggered.

Rivets in Wide Flange Cover Plates

109. When two or more cover plates are used, which project 3 inches or more beyond the edge of the flange angles, an extra line of rivets shall be driven along each edge, spaced not more than 16 times the thickness of the thinnest plate for tension flanges, and not more than 12 times the thickness of the thinnest plate for compression flanges.

Edge Distance

110. The minimum distance from the centre of any rivet hole to a sheared edge shall be:—

1¾	inches	for	1	inch	rivets
1½	"	"	⅞	"	"
1¼	"	"	¾	"	"
1⅛	"	"	⅝	"	"

and to a rolled edge shall be:—

1½	inches	for	1	inch	rivets
1¼	"	"	⅞	"	"
1⅛	"	"	¾	"	"
1	"	"	⅝	"	"

The maximum distance from any edge shall be 8 times the thickness of the thinnest outside plate, but not more than 6 inches.

Maximum Diameter of Rivets

111. The diameter of the rivets in any angle, channel, or beam, subject to calculated stress, shall not exceed 1/4 of the width of the leg in which the rivets are to be driven. In the minor parts:—

1	inch	rivets	may	be	used	in	3½	inch	legs
⅞	"	"	"	"	"	"	3	"	"
¾	"	"	"	"	"	"	2½	"	"
⅝	"	"	"	"	"	"	2	"	"

Long Rivets

112. Rivets subject to calculated stress and whose grip exceeds 4½ diameters shall be increased in number at least 1 per cent. for each additional 1/16 inch of the grip. If the grip exceeds 6 times the diameter of the rivet, specially designed rivets shall be used.

Turned Bolts

113. Turned bolts may only be used in place of rivets by special permission of the Engineer.

Web Plates

114. Web plates of girders which have no top cover plates shall be set above and trimmed flush with the tops of the top flange angles. Web plates of girders which have top cover plates may be set not over 1/4 inch below the tops of top flange angles and also not over 1/4 inch above the bottoms of the bottom flange angles.

115. When web plates are spliced, not more than 1/4 inch clearance shall be allowed between ends of adjoining plates.

Strength of Connections

116. Tension members shall be connected or spliced for an axial stress equal to their net sectional area, in square inches, multiplied by 16 000 pounds per square inch. Compression members shall be connected for an axial stress equal to their gross sectional area in square inches, multiplied by 12 500 pounds per square inch but not for a greater stress than 50 per cent. above the maximum stress to be carried by the member. Truss members subject to reversal of stress shall be connected for an axial stress equal to the arithmetical sum of the maximum resultant axial stresses of both kinds. Lateral, longitudinal and transverse bracing, when subject to reversal of stress, shall be connected for the maximum value, whether in tension or compression.

Compression Splices

117. Compression members abutting on a pin shall have sufficient bearing thereon to transmit the entire thrust without exceeding the allowable unit bearing. In riveted structures, continuous compression members, such as chords and trestle posts, shall have faced ends and full contact bearings at the joints when riveted. All joints in compression members, where pins are not used, shall be spliced for an axial stress equal to the gross sectional area of the smaller abutting member, in square inches, multiplied by 12 500 pounds per square inch.

118. All connections and splices shall be, as nearly as practicable, symmetrical about the axes of the members connected thereby.

Minimum Connections

119. No member or component part thereof, except lattice bars or fillers, shall be spliced or connected by fewer than 3 rivets.

Stringer Connections

120. Connection angles shall be designed to carry the entire load, irrespective of any shelf angles which may be provided to support stringers during erection.

Indirect Splices

121. Where splice plates are not in direct contact with the parts which they connect, the number of rivets therein, which would otherwise be required for a contact splice, shall be increased by 10 per cent. for each intervening plate.

Fillers

122. Rivets carrying stress and passing through fillers shall be increased in number 1 per cent. for each 1/16 inch of thickness of fillers, and the additional rivets when practicable shall be outside of the connection.

Arrangement of Splice Materials

123. The splice materials shall be so arranged that the strength of each component part of the member spliced, including legs of angles, flanges and webs of beams and channels, etc., will be fully developed.

Tie Plates and Diaphragms

124. The open sides of compression members shall be provided with tie plates as near the ends as practicable, and if located farther from the entersection point than 12 times the width of either of the flanges to be connected, diaphragms shall be added. Tie plates shall also be provided at intermediate points where the latticing is interrupted.

125. In main members, the end tie plates shall have a length of not less than 1½ times, and intermediate tie plates a length of not less than the perpendicular distance between the lines of rivets connecting them to the flanges; their thickness shall be not less than 1/50 of the distance between connecting lines of rivets.

126. When intermediate tie plates are used with tension members instead of latticing, they shall be spaced not farther apart in the clear than 15 times the width of the flange to which they are attached, and they shall be connected to the member by not fewer than 3 rivets on each side.

Latticing

127. Compression members shall be designed to resist a transverse shear equal to 3 per cent. of the axial stress in the member, by latticing, tie plates, or other means. This shear shall be considered as divided equally among all stiffening parts in parallel planes.

Minimum Size of Lattice Bars

128. The minimum width of lattice bars shall be:—

3	inches	for	1	inch	rivets
2¾	"	"	⅞	"	"
2½	"	"	¾	"	"
2	"	"	⅝	"	"

The minimum thickness shall be 1/40 of the distance between end rivets in the case of single latticing; and 1/60 of this distance for double latticing, riveted at the intersections. Shapes of equivalent strength may be used instead of flats.

Inclination and Spacing of Lattice Bars

129. Lattice bars shall generally be inclined at an angle of about 60 degrees to the axis of the member when single latticing is used; and they shall be inclined at an angle of not less than 45 degrees with double latticing; furthermore, the maximum spacing of lattice bars shall be such that the ratio l/r for the portion of single flange between consecutive connections will be smaller than this ratio for the member as a whole.

Expansion

130. Provision for expansion, to the extent of 1 inch for each 100 feet, shall be made for all bridges. Spans of less than 80 feet may be arranged to slide upon steel plates with smooth surfaces; but spans of 80 feet and over shall be provided with turned rollers or rockers, or with special sliding bearings, as described below.

Pier Members

130A. All pier members shall be made in accordance with the Railway Company's Standard Drawings.

Rollers

131. Expansion rollers shall be not less than 5 inches in diameter; they shall be connected together by substantial side bars; and shall be effectually guided so as to prevent lateral movement, skewing or creeping. The rollers and bearing plates shall be protected from dirt and water, as far as possible, by suitable curtain plates; and the whole construction shall be such that water will not be retained therein, and that it may be easily inspected and cleaned.

132. Neither rollers nor rockers shall be used for expansion bearings at the top of trestle posts.

Special Sliding Bearings

133. Sliding plates for the expansion bearings of spans of 80 feet and over shall be of hard bronze, or of some other hard non-corrosive material; they shall be chamfered at the ends, and shall be held securely in position; furthermore, they shall be arranged so that the sliding surfaces thereof cannot become clogged by dirt.

Shoes and Bed Plates

134. Shoes and beds shall be designed for rigidity and stability and to distribute the total reaction uniformly without exceeding the Unit Stress; they shall be of cast or rolled steel. Spans 30 feet and longer shall have hinged or disc bearings at each end unless otherwise specified.

Inclined Bearings

135. For spans on an inclined grade and without hinged or disc bearings, the bed or masonry plates shall be beveled so that the masonry surfaces will be level .

Lead

135A. One sheet of lead, 1/4 inch in thickness shall be supplied to go between each pier member and the masonry bridge seat. Lead sheets shall be 1 inch larger each way than the pier member castings or bed plates under which they are designed to be placed.

Anchor Bolts

136. Anchor bolts shall not be less than 1¼ inches in diameter; and when subject to tension they shall be long enough to engage a mass of masonry weighing not less than 1½ times the amount of the uplift.

Camber

137. Unless otherwise specified, trusses shall be cambered for the dead load plus one-half the live load without Impact.

Name Plates

137A. There shall be one name plate provided for and fastened to each span of any bridge. Name plates shall be made in accordance with the Railway Company's Standard Drawings to show the name of the Railway Company, the date of manufacture, and the Contractor's Name and Address.

Number Boards

137B. One or more number boards shall be provided for each bridge. These shall be in accordance with the Railway Company's Standard Drawings. In the case of through bridges, where numbers can be painted on the end posts of spans, no special number boards will be required.

Workmanship

General

138. All parts forming a structure shall be built in accordance with drawings approved by the Engineer. The workmanship and finish shall conform to the best practice in modern bridge works. Materials shall have clean surfaces before being worked in the shop.

Straightening

139. Rolled material, before being laid off or worked, must be straight. If straightening or flattening is necessary, it shall be done by methods that will not injure the material. Sharp kinks or bends will be cause for rejection.

140. Finished members shall be true to line and free from twists, bends, and open joints.

Finish

141. Shearing and chipping shall be neatly and accurately done, and all portions of the work exposed to view shall be neatly finished. When specified by the Engineer, sheared edges of all material over 5/8 inch thick in main members, including splice and connection plates, shall be planed at least 1/8 inch. Re-entrant cuts shall be filleted before being cut.

Rivet Holes

142. Rivet holes in main members shall either be drilled from the solid, or subpunched and reamed. In lateral and sway bracing, and in secondary parts such as tie plates, lattice bars, etc., rivet holes may be punched full size.

Punched Holes

143. Where reaming is not required, the diameter of the punch shall not be more than 1/16 inch greater than the nominal diameter of the rivet; nor the diameter of the die more than 1/8 inch greater than that of the punch. Punching shall be accurately done. Drifting to enlarge unfair holes will not be allowed; but if holes must be enlarged to admit the rivets, they shall be reamed. Poor matching of holes will be cause for rejection.

Reamed Holes

144. In sub-punched and reamed work, the holes shall be punched 3/16 inch smaller, and, after assembling, reamed 1/16 inch larger than the nominal diameter of the rivet. The diameter of the punch used shall be 3/16 inch smaller than the nominal diameter of the rivet, and the diameter of the die not more than 3/32 inch larger than the diameter of the punch.

145. Reaming shall be done with twist drills without the use of any lubricant. Hand-held reamers shall preferably not be used. Outside burrs shall be removed with a tool making a 1/16 inch fillet.

Accuracy of Punching for Reamed Work

146. In sub-punched and reamed work, the punching shall be so accurately done that, after assembling and before reaming, a cylindrical pin 1/8 inch smaller in diameter than the nominal size of the punched hole may be entered, perpendicular to the face of the member, without drifting, in at least 75 per cent. of any group of contiguous holes in the same plane. If this requirement is not fulfilled, the badly punched pieces shall be rejected. If 5 per cent. of the holes will not pass a pin 3/16 inch smaller in diameter than the nominal size of the punched hole, this shall be cause for rejection.

Reaming after Assembling

147. Reaming shall be done after the pieces forming a built member are assembled and so firmly bolted together that the surfaces are in close contact. Before riveting they shall be taken apart, if necessary, and any shavings removed. When it is necessary to take the members apart for shipping or handling, the respective pieces reamed together shall be so marked that they may be re-assembled in the same position in the final setting up. No interchange of such reamed parts will be permitted.

Accuracy of Reaming and Drilling

148. When holes are reamed or drilled, after assembling of parts, 85 per cent. of any group of contiguous holes in the same plane shall, after reaming or drilling, show no offset greater than 1/32 inch between adjacent thicknesses of metal.

Drilled Holes

149. Holes in flanges of rolled beams and channels and in all steel of greater thickness than 3/4 inch shall be drilled from the solid. Outside burrs shall be removed from drilled holes.

Field Connections

150. All field connections, except those in lateral, longitudinal and sway bracing and connection plates for same, shall be reamed or drilled to approved steel templates, otherwise the connecting members shall be assembled in the shop and then reamed and drilled.

Shop Assembling

151. The parts of riveted members shall be well pinned and firmly drawn together with bolts before riveting is commenced. The drifting done during assembling shall be only such as to bring the parts into position, and not sufficient to enlarge the holes or distort the metal. Surfaces in contact shall be painted before being assembled. Bolts in field connection holes shall be left in place.

Match Marking

152. Connecting parts assembled in the shop for the purpose of reaming or drilling holes in field connections shall be match marked, and a copy of diagram showing such marks shall be furnished to the Engineer.

Abutting Joints

153. Abutting joints in compression members and girder flanges, and, where so specified on the drawings, in tension members, shall be faced and brought to an even bearing. Where joints are not faced, the opening shall not exceed 1/8 inch.

Fit of Stiffeners

154. Stiffeners under the top flanges of deck girders and at all bearing points shall be milled or ground to bear against the flange angles. Other stiffeners must fit sufficiently tight against the flange angles to exclude water after being painted.

Splice Plates and Fillers

155. Fillers and splice plates shall fit within 1/4 inch at each end, unless otherwise instructed.

Floor Beams and Stringers

156. The ends of all floor beams and stringers shall be milled to exact length after the end connection angles have been riveted in place. Milling is to be done in such a manner that the ends of all main material, as well as the faces of connection angles, will be milled to a true even surface exactly square (unless otherwise required) with the axis of the main member. The minimum thickness of the end connection angles, after milling, shall be 1/2 inch.

Rivets

157. The size of rivets called for on the plans shall be understood as their nominal diameter before heating.

158. Rivet heads, when not countersunk or flattened, shall be of approved shape and of uniform size for the same diameter of rivet. Rivet heads shall be full, neatly made, concentric with the rivet holes, and in full contact with the surface of the member.

Riveting

159. Rivets shall be heated uniformly to a light cherry red and driven while hot. Rivets, when heated and ready for driving, shall be free from slag, scale and carbon deposit. When driven they shall completely fill the holes. Loose, burned or otherwise defective rivets shall be replaced. In removing rivets, care shall be taken not to injure the adjacent metal, and, if necessary, they shall be drilled out. Caulking or recupping will not be permitted.

160. Rivets shall be driven by pressure riveters where practicable. The riveters shall retain the pressure after the upsetting is completed.

Field Rivets

161. Field rivets shall be furnished in excess of the nominal number required, to the amount of 15 per cent. plus 5 rivets, for each size and length.

162. Field rivets shall be carefully selected and shall be free from fins on the under sides of the head.

Turned Bolts

163. Where turned bolts are used to transmit shear, the holes shall be reamed parallel and the bolts shall make a tight fit, with the threads entirely outside of the holes. A washer not less than 1/4 inch thick shall be used under each nut.

Eye Bars

164. Eye bars shall be straight and true to size, and shall be free from twists, folds in the neck or head, or any other defect. Heads shall be made by upsetting, rolling or forging. Welds will not be allowed. The form of the heads may be determined by the dies in use at the works where the eye bars are to be made, if satisfactory to the Engineer; but the Manufacturer shall guarantee the bars to break in the body when tested to rupture. The thickness of head and neck shall not vary more than 1/16 inch from that specified.

Boring Eye Bars

165. Before boring, each eye bar shall be properly annealed and carefully straightened. Pin holes shall be on the centre line of the eye bar and in the centre of the heads. Bars of the same length shall be bored so accurately that, when placed together, pins which are 1/32 inch smaller in diameter than the pin holes can be passed through the holes at both ends of the bars, at the same time and without forcing.

Pin Holes

166. Pin holes shall be bored true to gauge, smooth and straight, at right angles to the axis of the member, and parallel to each other, unless otherwise called for. Boring shall be done only after the member has been riveted up.

167. The distance centre to centre of pin holes shall be correct within 1/32 inch: the diameter of the holes shall be not more than 1/50 inch larger than that of the pin, for pins up to 5 inches in diameter; and 1/32 inch for larger pins.

Pilot Nuts

168. Pilot and driving nuts shall be furnished for each size of pin.

Pins and Rollers

169. Pins and rollers shall be accurately turned to gauge; they shall be straight and smooth and entirely free from flaws.

Forging Pins

170. Pins larger than 7 inches in diameter shall be forged and annealed.

Screw Threads

171. Screw threads shall make a tight fit in the nuts; when over 1⅜ inches in diameter they shall be made with 6 threads per inch.

Bearing Surfaces Planed

172. The top and the bottom surfaces of shoe and cap plates of columns and bed plates, except surfaces in contact with masonry, shall be planed or hot-straightened, and parts of members in contact with them shall be faced to fit. Connection angles for base plates and cap plates shall be riveted to compression members before the members are faced.

173. Shoe plates of plate girders shall have full contact with the girder flanges. Shoe and bed plates shall be planed or hot-straightened. Cast bed plates shall be planed on the surfaces in contact with steel, and shall have the bottom surfaces resting on masonry rough finished.

Annealing

174. Excepting minor details, steel which has been partially heated shall be properly annealed.

Castings

175. Castings shall be free from large or injurious blow-holes; and steel castings shall be annealed.

Welds

176. Welds in steel will not be allowed.

Weighing And Shipping

Weight Paid For

177. The payment for pound price contracts shall be based upon the scale weight of the metal in the fabricated structure, (including field rivets) shipped. The weight of the field paint, cement and erection bolts, boxes and barrels used for packing, and material used for staying or supporting members on cars, shall be excluded.

Variation in Weight

178A. If the weight of any member is more than 2½ per cent. under the computed weight, it shall be cause for rejection. The greatest allowable variation of the total scale weight of any structure from the weights computed from the approved shop drawings shall be 2 per cent. The Railway Company will not pay for any weight in excess of 2 per cent. above the computed weight, and when actual scale weights are not obtained the computed weights with no percentage allowance shall be used for making payments.

Computed Weight

179. The computed weights of rolled shapes, and of plates up to and including 36 inches in width, shall be calculated on the basis of their dimensions as shown on the approved shop drawings, deducting for copes, cuts and open holes.

180. The computed weights of plates wider than 36 inches shall be calculated on the basis of their dimensions as shown on the approved shop drawings, deducting for cuts and open holes. To this shall be added one-half of the allowed percentage for over-run in weight, as given in the specification for the material.

181. The weight of the heads of shop driven rivets shall be included in the computed weight.

182. The computed weight of castings shall be calculated from the dimensions shown on the approved shop drawings, with an addition of 10 per cent. for fillets and over-run.

Weighing of Members

183. Finished work shall be weighed in the presence of the Inspector, if practicable. The Contractor shall furnish satisfactory scales, and shall do the handling of the material for weighing.

Marking and Shipping

184. Members weighing more than 5 tons shall have the weight marked thereon. Bolts and rivets of the same length and diameter, and loose nuts or washers of each size, shall be packed separately. Pins, other small parts, and small packages of bolts, rivets, washers and nuts shall be shipped in boxes, crates, kegs or barrels; and the gross weight of any package shall not exceed 200 lbs. A list and description of the contained materials shall be plainly marked on the outside of each package, box or crate.

185. Long girders shall be loaded and marked so that they will arrive at the bridge site in position for erection without turning.

Shipping Invoices

186. For each shipment, the Contractor shall furnish the Engineer with complete copies of shipping invoices, showing the scale weights of individual pieces.

Inspection

Inspectors

187A. At the time of awarding the contract, the Railway Company will name to the Contractor the person or persons authorized to act as Inspector.

Facilities for Inspection

188A. The Contractor shall allow the Inspector free access to his shops and to the mills at all times when work is being done on this contract, and he shall provide every reasonable facility to assist the Inspector in the inspection of both material and workmanship for the entire contract.

Material Orders

189. The Contractor shall furnish the Engineer with as many copies of material orders as the Engineer may direct.

Notice of Rolling

190. The Contractor shall give ample notice to the Inspector of the beginning of rolling at the mill and of work at the shop, so that the Inspector may be present. Any materials rolled or other materials manufactured or any shop work done before the Inspector has had due notice may be rejected.

Cost of Testing

191. The Contractor shall furnish, without charge, test specimens, as specified herein, and all labour, testing machines and tools necessary to make the specimen and full size tests.

Inspector's Authority

192. The Inspector shall have the power to reject materials or workmanship which do not come up to the requirements of this Specification; but, in case of dispute, the Contractor may appeal to the Engineer, whose decision shall be final.

Rejections

193. The acceptance of any material or finished members by the Inspector shall not be a bar to their subsequent rejection, if found defective. Rejected material and workmanship shall be replaced promptly or made good by the Contractor.

Eye Bars

194. When specified by the Engineer, one eye bar from each annealing charge shall be tested full size; but the number and size of bars to be tested shall be stipulated by the Engineer before the order shall have been placed at the mill. If such full size tests should not meet the requirements herein specified, all members represented thereby shall be rejected. The tests shall be made at the Contractor's expense.

195A. Eye bars thus tested which meet the requirements of this Specification shall be paid for by the Railway Company at the actual cost to the Contractor less scrap value. Bars which fail to meet the requirements of this Specification and all bars from rejected annealing charges shall be paid for by the Contractor.

196. Full size tests of carbon steel eye bars shall show a yield point of not less than 29 000 pounds per square inch, an ultimate strength of not less than 54 000 pounds per square inch, and an elongation of not less than 10 per cent., in a length of 18 feet, measured in the body of the bar. The fracture shall show a silky or fine granular structure throughout.

197. Full size tests of nickel steel eye bars shall show a yield point of not less than 48 000 pounds per square inch, an ultimate strength of not less than 85 000 and not more than 100 000 pounds per square inch, an elongation of not less than 10 per cent. in a length of 18 feet measured in the body of the bar, and a reduction of area of not less than 30 per cent. The fracture shall show a silky or fine granular structure throughout.

198. Should a test eye bar break in the head and yet develop the specified yield point, ultimate strength, elongation and character of fracture, the members represented thereby shall not be rejected, provided not more than one-third of the total number of bars tested fail in this manner.

199. The yield point shall be determined by the halt of the gauge of the testing machine.

Shop Painting

Paint

200A. Unless otherwise specified by the Engineer, all metal surfaces, except such as are to be encased in concrete, shall be given one coat of each of the Railway Company's Standard Paints Nos. 1, 2 and 3. One coat of paint No. 1 shall be put on in the shop and one coat of each of paints Nos. 2 and 3 shall be put on in the field as specified under "Erection". All paints shall be in accordance with the Railway Company's Standard Specification K1W-9.1.

Cleaning in Shop

201. Before painting, all metal surfaces shall be thoroughly scraped and cleaned of rust, scale, and dirt, either with sand-blast, steel scrapers, or stiff wire brushes; finally, the surfaces shall be dusted off with stiff bristle brushes. Oil, paraffin and grease shall be removed by wiping with benzine or gasoline.

Surfaces in Contact

202A. Surfaces coming in contact shall be cleaned and given one coat of paint No. 1 on each surface before assembling.

Erection Marks

203. Erection marks shall be painted on painted surfaces and must be clear and distinct when materials are shipped.

Inaccessible Surfaces

204A. All surfaces which may be inaccessible after erection, including top surfaces of stringers, eye bar heads, ends of posts, chords, etc., shall have three coats of paint before erection, of which two shall be applied in the shop.

Machine Finished Surfaces

205. Machine finished surfaces (except abutting joints and base plates) shall be coated with a mixture of white lead and tallow, applied hot as soon as the surfaces are finished and accepted by the Inspector.

Conditions for Painting

206. Painting shall not be done in wet or freezing weather, except under cover; and the steel shall be free from moisture or frost when the paint is applied. Material painted under cover in damp or freezing weather, shall be kept under cover until the paint is dry.

Brushes

206A. Brushes for painting steelwork shall be cylindrical in shape with a diameter of not over 2½ inches. All brushes must be "bridled "or bound so as to leave not over 2½ inches of free bristle. No brushes are to be used which have an overall length when new, from tip of bristle to end of handles, exceeding 14 inches.

Mixing of Paint

207. The paint shall be thoroughly stirred just before applying, and the pigments shall be kept in suspension.

Application

208. The paint shall be of proper working consistency and each coat shall be thoroughly brushed out and allowed to dry completely before the application of the next coat. The paint shall be carefully worked into all joints and open spaces. The shop coat must be dry before loading on the cars.

Paints

209A. All paints shall be in accordance with the Railway Company's Standard Specifications, or meet with the Engineer's approval. No paints are to be used unless the containers bear the seal of the Railway Company's Inspectors and the Contractor has been notified that the paint is satisfactory for use. No addition of any thinner, adulterant or other substance is to be made to any paint at any time after the container is opened.

Erection

General

210. Unless otherwise specified, the work of erection shall include the furnishing of all necessary tools, erection bolts and equipment, the unloading of the material at the site, and the furnishing and construction of any falsework required. The Contractor shall provide for the cost of labour and all other incidental expenses necessary for the erection and completion of the structure.

210A. Unless otherwise specified, the Contractor for the erection of the new structure shall also remove any or all existing timber or steel bridge structures which may be replaced by the new structure or which may be specified by the Engineer.

211A. When the erection work is finally completed, the Contractor shall remove from the site all falsework, rejected materials and debris caused by his operations and leave the site in as clean and tidy a condition as he found same. This work shall be done without any additional cost to the Railway Company.

Unloading and Storing Materials

212A. Cars containing materials or plant shall be promptly unloaded by the Contractor upon delivery, and in case of failure to do so the Contractor shall be liable for the Railway Company's regular demurrage charges.

213A. All materials shall be handled during unloading with the greatest care possible to prevent injury to any of the members, and also to prevent as far as possible any injury to the paint. Materials shall be stored on skids or blocking placed so as to keep same clear of the ground and of any standing water. All materials shall be stored at such locations as will not interfere with the operations of the Railway Company.

214. The Contractor, while unloading materials, shall compare and check off each piece with the original shipping list and shall report promptly any shortage discovered.

Material Injured in Transit

215. All small bends or twists received by members during transportation shall be rectified before such members are put in place. Any serious bends or damage shall be reported at once to the Engineer for instructions.

Riveting

216. All rivets shall be power driven unless otherwise authorized by the Engineer.

217. In driving rivets, the bucker and the hammer snap shall be placed directly opposite each other and at right angles to the riveted surfaces, and no tilting of snaps will be allowed. Rivet heads shall be well formed, concentric with the shaft of the rivet, and shall hold the several members together tightly.

218. Rivets shall be heated uniformly to a light cherry red and driven while hot. Rivets, when heated and ready for driving, shall be free from slag, scale and carbon deposit. When driven, they shall completely fill the holes. Loose, burned or otherwise defective rivets shall be replaced. In removing rivets, care shall be taken not to injure the adjacent metal and, if necessary, they shall be drilled out. Caulking or re-cupping will not be permitted.

Turned Bolts

219. All turned bolts shall be perfectly tight in the holes and shall be burred or otherwise checked to prevent the nuts from becoming loose.

Unfilled Holes

220. No unfilled bolt or rivet holes shall be left in any part of the structure.

Decks

221. Unless otherwise specified, the Contractor shall frame and place all timber in the bridge deck.

222A. Unless otherwise specified, the Railway Company will supply the timber necessary for the deck delivered at the bridge site.

223A. The Contractor shall give all assistance required of him by the Railway Company's forces to help get the track connected up ready for traffic after any interruptions to same caused in any way by his operations. The cost of this work shall be included in the Contractor's tender for framing and placing deck timber, or where there is no timber deck, this cost shall be included in the tender rate for erection of the new structure.

Maintenance of Traffic

224A. The Contractor shall not, without the special permission of the Engineer, interfere with the operations of the Railway Company.

225A. Changes in any structure supporting operating tracks, or changes in the approach tracks, shall be undertaken only under the direct control and supervision of the Railway Company.

Removal of Old Structure

226A. When an existing structure is to be removed, this work shall be done as directed by the Engineer.

227A. Unless otherwise specified, old timber structures shall be completely dismantled. The timbers and iron work shall be piled separately at some convenient location as directed, or loaded in cars supplied by the Railway Company for this purpose.

228. Steel spans shall be removed without dismantling if same can be handled and loaded on cars for shipment. If spans are cut apart, each span shall first be fully match-marked, and also marked to show the span number and the mile and subdivision location from which it is being taken. All markings shall be done with white paint. The match-marking diagram shall be approved by the Engineer before spans are marked and removed.

Anchor Bolts

229. After any span has been erected in place and pier members set, the Contractor shall drill all necessary anchor bolt holes in the masonry and set anchor bolts in Portland cement grout.

230. In the case of Viaducts or other structures where the anchor bolts have been set in open holes in the masonry during construction, the Contractor shall fill these holes with Portland cement grout after erection of the steel.

231. When erection is carried on during freezing weather, the Contractor shall keep all anchor bolt holes free of water.

231A. All work in connection with placing anchor bolts shall be done without additional cost to the Railway Company.

Sidings

231B. Where necessary for erection purposes, the Railway Company will, at its own expense, furnish siding accommodation at or near each bridge site, or the Railway Company may, at its own option, supply free of charge to the Contractor a locomotive and crew for same to transport materials and equipment to and from the bridge site during actual erection operations.

Derrick Car

231C. Contractor's self-propelling derrick car, when used on the main line, shall be in charge of a Railway Company Conductor who will be provided free of charge by the Railway Company. The Contractor shall state in his tender whether or not he will execute the erection work with a self-propelling car. If flagmen are required they will be furnished and paid for by the Railway Company.

Locomotive

231D. If a locomotive is required (other than that supplied by the Railway Company in lieu of siding accommodation) in the execution of the work, the Contractor may obtain one from the Railway Company at the rate of $75.00 per eight hour day or fraction thereof. This charge is to include engine, tender, coal, water, crew and all incidental expenses.

Transportation

231E. All materials, tools, equipment and employees on these Contracts shall be routed over the Canadian National Railway's Lines from the closest junction with other connecting Railway. No reduced passenger or freight rates will be granted.

Cleaning Steel

232. After erection, the steelwork is to be cleaned of all dirt, rust and loose or broken paint.

Painting

233A. All rivet and bolt heads and bare or scratched spots shall be given one coat of paint No. 1 before field coats Nos. 2 and 3 are applied.

234A. The entire structure, except metal to be encased in concrete, shall be painted by the Contractor with either the one or the two coats of paint which have not been previously applied.

234B. All rivet and bolt heads, which are located on painted surfaces, are to be given one coat of each of the three standard paints.

235. Surfaces which are to be protected by concrete casing shall not be painted, and all such surfaces shall be left in a perfectly clean condition, free from all dirt, rust, grease or paint spots.

236. No painting shall be done in damp or foggy weather or at any time when the temperature of the steelwork is below 40° Fahrenheit. No paint shall be applied to surfaces which are not absolutely dry and clean.

Paint

237A. Unless otherwise specified by the Engineer, paints shall be supplied by the Contractor and shall be in accordance with the Railway Company's Standard Specification K1W.-9.1.

Mixing of Paint

238. The paint shall be thoroughly stirred just before applying, and the pigments shall be kept in suspension.

Brushes

238A. Brushes for painting steelwork shall be cylindrical in shape with a diameter of not over 2½ inches. All brushes shall be "bridled" or bound so as to leave not over

2½ inches of free bristle. No brushes are to be used which have an overall length when new, from tip of bristle to end of handles, exceeding 14 inches.

Application

239. The paint shall be of proper working consistency and each coat shall be thoroughly brushed out and allowed to dry completely before the application of the next coat. The paint shall be carefully worked into all joints and open spaces.

240. No paint shall be used unless the containers bear the seal of the Inspector and the Contractor has been notified that such paint is satisfactory for use.

Inspection

241. The Contractor shall allow the Inspector free access to all parts of the work at all times, and will facilitate in every reasonable manner the Inspector's duties in ensuring that all work is done in accordance with the plans and specifications.

Erection Inspector's Authority

242. The Inspector on erection work is authorized to reject, at any time during the progress of the work, any piece of material or any member which he may find defective in any manner or not in accordance with the detail plans. This material may be rejected notwithstanding any previous acceptance, and any pieces so rejected shall be replaced by the Contractor without extra charge.

B. & B. Master

242A. All erection work being done at each bridge site shall be performed under the supervision of the Bridge and Building Master.

Special Ordinances

243A. The Contractor shall comply with all special or local ordinances or regulations appertaining to the work, and shall protect the Railway Company against any claims due to lack of compliance with such ordinances or regulations.

APPROVED

C. B. BROWN
Engineering Assistant.

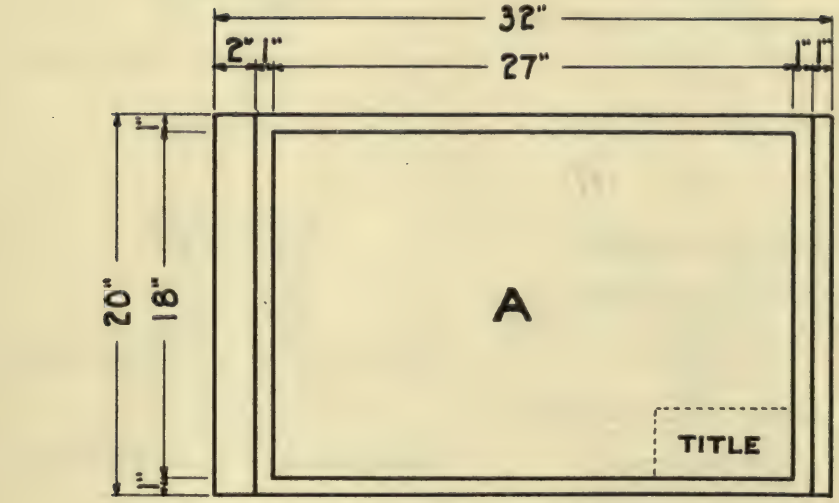
W. A. DUFF
Engineer of Standards.

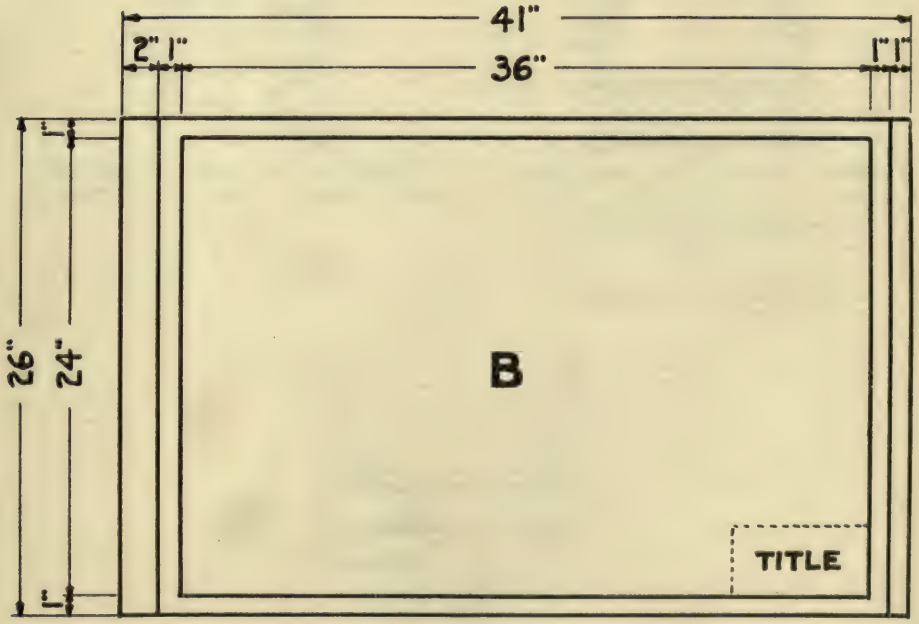
Office of Engineer of Standards,
Toronto, Ont.
May 1, 1922.

APPENDICES

APPENDIX I

DRAWING SIZES

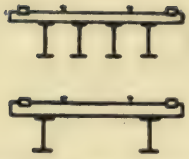




NOTE—All drawings made for any one Bridge must be on the same size sheet.

APPENDIX II

TYPES OF SPANS



Span may consist of any number of I Beams.

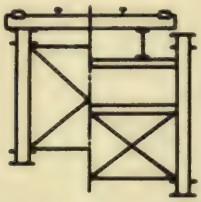
I

I BEAM SPAN

Timber deck carried on floor system above tops of Main Girders.

HTPG

HALF THROUGH PLATE GIRDER SPAN



Deck carried on top chords of Trusses or on floor system, with ties above top chords.

DT

DECK TRUSS SPAN

Timber deck carried directly on top flanges of Main Girders.

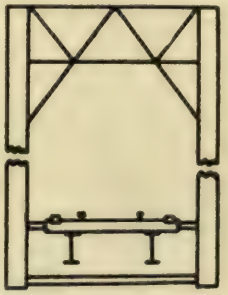
DPG

DECK PLATE GIRDER SPAN

Timber deck carried on floor system below tops of Main Girders.

TPG

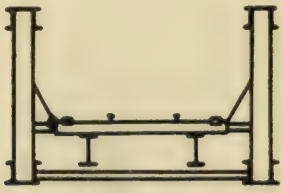
THROUGH PLATE GIRDER SPAN



Deck carried on floor system between Trusses and Trusses braced to each other above Track Clearance.

TT

THROUGH TRUSS SPAN



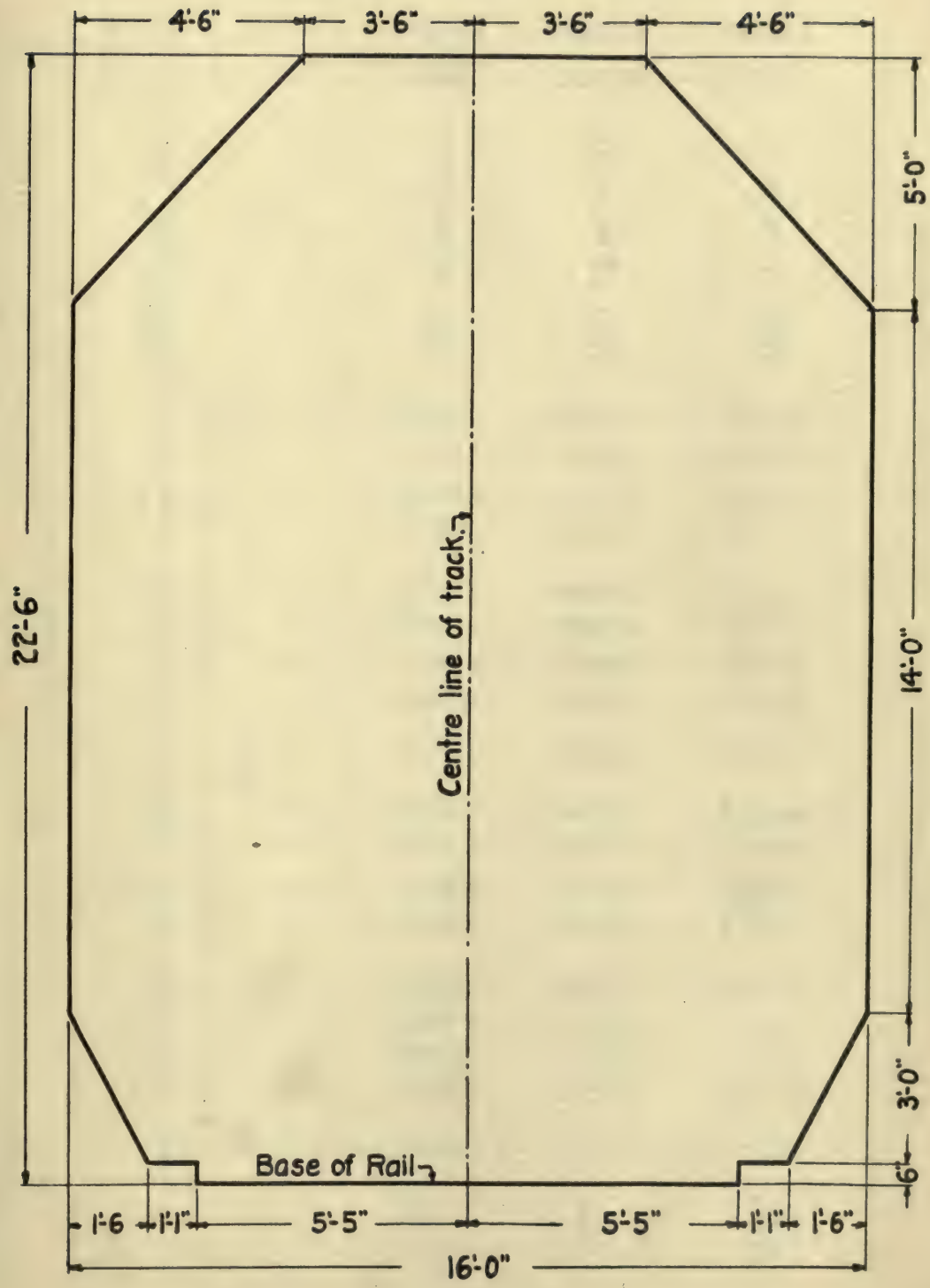
Through Truss Span with no overhead bracing.

PT

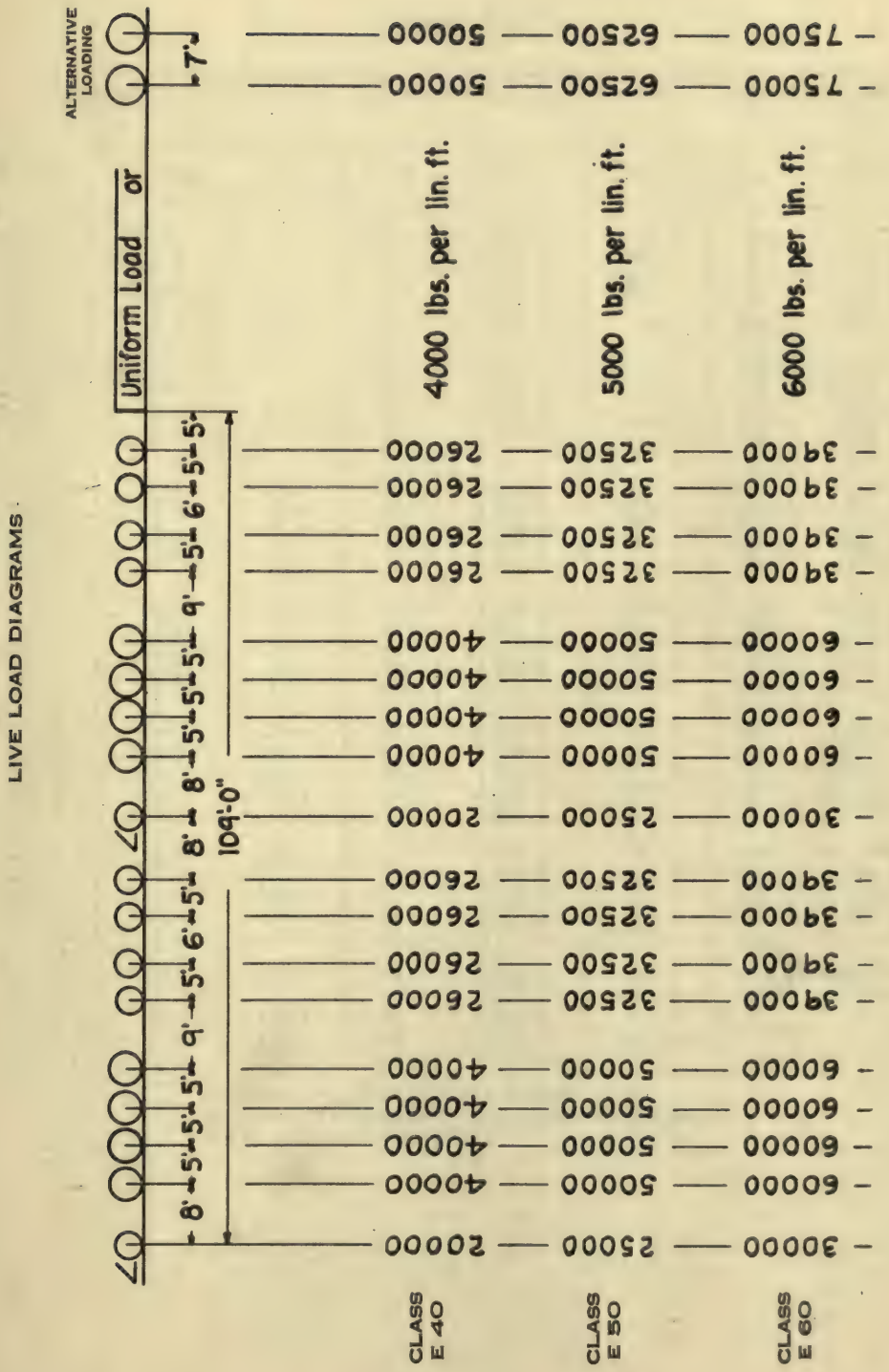
PONY TRUSS SPAN

APPENDIX III

CLEARANCE DIAGRAM



APPENDIX IV



NOTE—All wheel spacing given in feet. All loads given in pounds, and for one track.

APPENDIX V

TABLE OF MAXIMUM MOMENTS, SHEARS AND FLOOR BEAM CONCENTRATIONS COOPER'S E 50 LOADING AND 125 000 LBS. ON TWO AXLES 7 FT. APART

Span	Moment	End Shear	F.B. Concentrations
2 Axles			
8	62.3	35.1	
9	70.2	38.2	
10	78.0	40.6	Equal
11	85.8	42.6	to end
12	94.0	45.2	shear
13	117.0	45.6	
E50 Loading			
8	50.0	34.4	43.7
9	58.7	36.1	47.2
10	70.3	37.5	50.0
11	82.0	40.9	54.5
12	100.0	43.8	58.4
13	118.8	46.2	61.6
14	137.5	48.2	65.2
15	156.3	50.0	68.3
16	175.0	53.1	71.1
17	193.8	55.9	73.5
18	212.5	58.3	75.9
19	233.2	60.5	78.6
20	257.8	62.5	81.9
21	282.4	64.3	84.9
22	307.1	65.9	87.6
23	331.8	67.4	90.4
24	356.5	69.3	92.4
25	381.3	71.0	94.6
26	406.0	72.6	97.1
27	430.8	74.1	100.1
28	456.9	75.5	102.8
29	484.9	76.9	105.4
30	513.1	78.8	107.9
31	541.2	80.5	113.6
32	569.3	82.1	113.7
33	597.4	83.7	116.7
34	625.5	85.1	119.4
35	653.7	86.5	122.0

Span	Moment	End Shear
36	685.8	88.2
37	717.9	89.8
38	750.0	91.4
39	783.3	92.9
40	819.5	94.3
41	855.8	96.0
42	892.0	97.6
43	928.3	99.2
44	964.5	100.7
45	1 001.0	102.1
46	1 037.0	103.5
47	1 073.0	104.9
48	1 110.0	106.3
49	1 149.0	107.7
50	1 189.0	109.0
52	1 269.0	111.8
54	1 351.0	114.5
56	1 440.0	117.2
58	1 529.0	119.8
60	1 624.0	122.5
62	1 720.0	125.2
64	1 819.0	128.2
66	1 924.0	131.2
68	2 029.0	134.8
70	2 134.0	138.1
72	2 240.0	141.7
74	2 350.0	145.3
76	2 465.0	148.8
78	2 581.0	152.1
80	2 700.0	155.3
82	2 820.0	158.6
84	2 946.0	161.8
86	3 075.0	165.1
88	3 205.0	168.4
90	3 337.0	171.5

Span	Moment	End Shear
92	3 471.0	174.7
94	3 606.0	178.0
96	3 743.0	181.0
98	3 882.0	184.3
100	4 024.4	187.5
102	4 185.0	190.6
104	4 342.0	193.6
106	4 502.0	196.6
108	4 672.0	199.5
110	4 857.0	202.5
112	5 035.0	205.5
114	5 215.0	208.4
116	5 400.0	211.3
118	5 580.0	214.2
120	5 770.0	217.1
125	6 245.0	224.2
130	6 735.0	231.4
135	7 240.0	238.4
140	7 750.0	245.4
145	8 290.0	252.3
150	8 830.0	259.2
160	9 945.0	272.8
170	11 100.0	286.3
180	12 300.0	299.7
190	13 550.0	313.0
200	14 850.0	326.3
225	18 280.0	359.0
250	21 990.0	391.5
275	26 080.0	423.7
300	30 550.0	455.8
350	40 660.0	519.6
400	52 380.0	583.1

Moments in units of 1000 foot pounds.
Shears and F.B. concentrations in units of 1000 pounds.
All figures are for one rail only.

APPENDIX VI

SHEARING AND BEARING VALUES OF POWER-DRIVEN SHOP-RIVETS (SHEAR 12 000: BEARING 24 000)

Diam. of Rivet	Single Shear Value	Bearing Value for different Thicknesses of Metal												
		1/4	5/16	3/8	7/16	1/2	9/16	5/8	11/16	3/4	13/16	7/8	15/16	1
3/8	1 320	2 250	2 810	3 380	3 930									
1/2	2 360	3 000	3 740	4 500	5 240	6 000								
5/8	3 680	3 750	4 680	5 630	6 560	7 500	8 430	9 380						
3/4	5 300	4 500	5 620	6 750	7 780	9 000	10 120	11 250	12 370	13 500				
7/8	7 220	5 250	6 550	7 880	9 180	10 500	11 800	13 130	14 430	15 750	17 050	18 380	19 680	
1	9 430	6 000	7 490	9 000	10 490	12 000	13 490	15 000	16 490	18 000	19 490	21 000	22 490	24 000

SHEARING AND BEARING VALUES OF POWER-DRIVEN FIELD-RIVETS (SHEAR 10 000: BEARING 20 000)

Diam. of Rivet	Single Shear Value	Bearing Value for different Thicknesses of Metal												
		1/4	5/16	3/8	7/16	1/2	9/16	5/8	11/16	3/4	13/16	7/8	15/16	1
3/8	1 100	1 880	2 340	2 810										
1/2	1 960	2 500	3 130	3 750	4 380	5 000								
5/8	3 070	3 130	3 910	4 690	5 470	6 250	7 030	7 810						
3/4	4 420	3 750	4 690	5 630	6 560	7 500	8 440	9 380	10 310	11 250				
7/8	6 010	4 380	5 470	6 570	7 660	8 750	9 840	10 940	12 030	13 130	14 220	15 310	16 410	
1	7 850	5 000	6 250	7 500	8 750	10 000	11 250	12 500	13 750	15 000	16 250	17 500	18 750	20 000

SHEARING AND BEARING VALUES OF HAND-DRIVEN RIVETS AND TURNED-BOLTS (SHEAR 8 000; BEARING 16 000)

Diam. of Rivet	Single Shear Value	Bearing Value for different Thicknesses of Metal												
		1/4	5/16	3/8	7/16	1/2	9/16	5/8	11/16	3/4	13/16	7/8	15/16	1
3/8	880	1 500	1 880	2 250										
1/2	1 570	2 000	2 500	3 000	3 500	4 000								
5/8	2 450	2 500	3 120	3 750	4 370	5 000	5 630	6 250						
3/4	3 530	3 000	3 750	4 500	5 250	6 000	6 880	7 500	8 250	9 000				
7/8	4 810	3 500	4 370	5 250	6 120	7 000	7 880	8 750	9 620	10 500	11 370	12 250	13 120	
1	6 280	4 000	5 000	6 000	7 000	8 000	9 000	10 000	11 000	12 000	13 000	14 000	15 000	16 000

Values above or to right of upper zig-zag lines are greater than double shear.
Values between upper and lower zig-zag lines are less than double and greater than single shear.
Values below or to left of lower zig-zag lines are less than single shear.

APPENDIX VII

SPECIFICATION FOR STRUCTURAL STEEL FOR BRIDGES

(In substantial agreement with A.S.T.M. Specification A7-21)

MANUFACTURE

Process

1. The steel shall be made by the open-hearth process.

CHEMICAL PROPERTIES AND TESTS

Chemical Composition

2. The steel shall conform to the following requirements as to chemical composition:

	Structural Steel	Rivet Steel
Phosphorus, Acid	not over 0.06	not over 0.04 per cent.
Phosphorus, Basic	" " 0.04	" " 0.04 " "
Sulphur	" " 0.05	" " 0.045 " "

Ladle Analyses

3. An analysis of each melt of steel shall be made by the Manufacturer to determine the percentages of carbon, manganese, phosphorus and sulphur. This analysis shall be made from a test ingot taken during the pouring of the melt. The chemical composition thus determined shall be reported to the Engineer and shall conform to the requirements specified above.

Check Analyses

4. Analyses may be made by the Engineer from finished material representing each melt. The phosphorus and sulphur content thus determined shall not exceed that specified above by more than 25 per cent.

PHYSICAL PROPERTIES AND TESTS

Tension Tests

5. The material shall conform to the following requirements as to tensile properties, except as modified hereinafter:

Properties Considered	Structural Steel	Rivet Steel
Tensile strength, lbs. per sq. inch	55 000—65 000	46 000—56 000
Yield Point, min., lbs. per sq. inch	0.5 tens. str.	0.5 tens. str.
Elongation in 8 ins., min., per cent	$\frac{1\,500\,000}{\text{Tens. str.}}$	$\frac{1\,500\,000}{\text{Tens. str.}}$
Elongation in 2 ins., min., per cent	22	.....

Specimen Tension Tests of Eyebar Material

6. In order to meet the required minimum tensile strength of full-sized annealed eyebars, the Engineer may determine the tensile strength to be obtained in specimen tests; the range shall not exceed 14 000 lbs. per sq. inch, and the maximum shall not exceed 74 000 lbs. per sq. inch. The material shall conform to the requirements as to physical properties (other than tensile strength) specified under "Tension Tests" above, and under "Modifications in Elongation" and "Bend Tests" below.

Yield Point

7. The yield point shall be determined by the drop of the beam of the testing machine.

Modifications in Elongation

8. For structural steel over 3/4 inch in thickness, a deduction of 0.25 from the percentage of elongation in 8 inches specified above shall be made for each increase of 1/32 inch in thickness above 3/4 inch to a minimum of 18 per cent.

9. For structural steel under 5/16 inch in thickness, a deduction of 1.25 from the percentage of elongation in 8 inches specified above shall be made for each decrease of 1/32 inch in thickness below 5/16 inch.

Bend Tests

10. The test specimens for plates, shapes and bars (except those for eyebar flats, for pins, rollers and other bars when 1 x 1/2 inch in section, and for rivet steel) shall bend cold through 180 degrees without cracking on the outside of the bent portion, as follows: for material 3/4 inch or under in thickness, flat on themselves; for material over 3/4 inch to and including 1¼ inches in thickness, around a pin the diameter of which is equal to the thickness of the specimen; and for material over 1¼ inches in thickness, around a pin the diameter of which is equal to twice the thickness of the specimen.

11. The test specimens for eyebar flats shall bend cold through 180 degrees without cracking on the outside of the bent portion, as follows: for material 3/4 inch or under in thickness, around a pin the diameter of which is equal to the thickness of the specimen; for material over 3/4 inch to and including 1¼ inches in thickness, around a pin the diameter of which is equal to twice the thickness of the specimen; and for material over 1¼ inches in thickness, around a pin the diameter of which is equal to three times the thickness of the specimen.

12. The test specimens for pins, rollers and other bars when 1 x 1/2 inch in section, when prepared as specified below under "Test Specimens", shall bend cold through 180 degrees around a one inch pin without cracking on the outside of the bent portion.

13. The test specimens for rivet steel shall bend cold through 180 degrees flat on themselves without cracking on the outside of the bent portion.

Test Specimens

Test Specimens

14. Test specimens shall be prepared for testing from the material in its rolled or forged condition, except when it is specified to be annealed; in which case the test specimens shall be prepared from the material as annealed for use, or from a short length of a full section similarly treated.

15. Test specimens shall be taken longitudinally, and, except as otherwise specified herein, shall be of the full thickness or diameter of material as rolled.

16. Test specimens for plates, shapes, and flats may be machined to the form and dimensions shown in Fig. 1, or with both edges parallel; except that bend test specimens for eyebar flats may have three rolled sides.

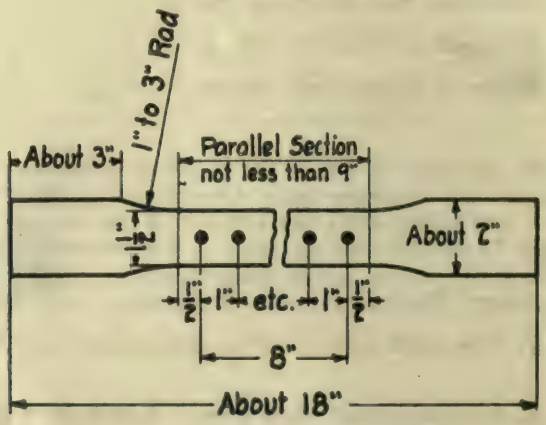


Fig. 1

17. Tension test specimens for plates and eyebar flats over 1½ inches in thickness, and bend test specimens for plates over 1½ inches in thickness, may be machined to a thickness or diameter of at least 3/4 inch for a length of at least 9 inches.

18. Test specimens for bars over 1½ inches in thickness or diameter may be machined to a thickness or diameter of at least 3/4 inch for a length of at least 9 inches; or tension test specimens may conform to the dimensions shown in Fig. 2, in which case, the ends shall be of a form to fit the holders of the testing machine in such a way that the load shall be axial. Bend test specimens may be 1 x 1/2 inch in section.

19. Tension test specimens for pins and rollers shall conform to the dime shown in Fig. 2. In this case the ends shall be of a form to fit the holders of the testing machine in such a way that the load shall be axial. Bend test specimens shall be 1 x 1/2 inch in section.

20. The tension test specimens shown in Fig. 2 and the 1 x 1/2 inch bend test specimens for pins and rollers shall be taken so that the axis is 1 inch from the surface; and for other bars over 1½ inches in thickness or diameter, midway between the centre and surface.

21. The machined sides of rectangular bend test specimens may have the corners rounded to a radius not over 1/16 inch.

22. Test specimens for rivet bars which have been cold drawn shall be normalized before testing.

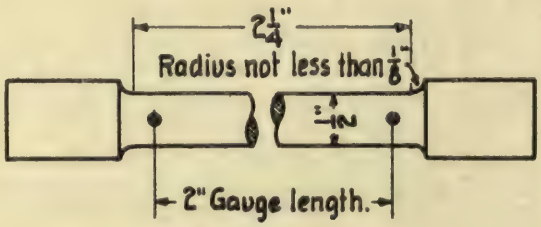


Fig. 2

Note—The gauge-length, parallel portions and fillets shall be as shown; but the ends may be of any form which will fit the holders of the testing machine.

Number of Tests

23. One tension and one bend test shall be made from each melt; except that if material from one melt differs 3/8 inch or more in thickness, one tension and one bend test shall be made from both the thickest and the thinnest material rolled.

24. If any test specimen shows defective machining or develops flaws, it may be discarded and another specimen substituted.

Retests

25. If the percentage of elongation of any tension test specimen is less than that specified under "Tension Tests" and any part of the fracture is more than 3/4 inch from the centre of the gauge length of a 2 inch specimen or is outside the middle third of the gauge length of an 8 inch specimen, as indicated by scribe-scratches marked on the specimen before testing, a retest shall be allowed.

Character of Fracture

26. Test specimens of structural or rivet steel shall show a fracture of uniform, silky appearance; of bluish grey or dove colour; and entirely free from granular, black and brilliant specks.

Finish

Defects

27. Finished rolled material shall be free from cracks, flaws, injurious seams, blisters, ragged and imperfect edges, and other surface defects. It shall have a smooth finish, and shall be straightened in the mill before shipment.

Permissible Variations In Weight And Thickness

Permissible Variations

28. The cross-section or weight of each piece of steel shall not vary more than 2.5 per cent. from that specified; except in the case of sheared plates, which shall be covered by the following permissible variations. One cubic inch of rolled steel is assumed to weigh 0.2833 lb.

29. When ordered to weight per square foot, the weight of each lot in each shipment shall not vary from the weight ordered more than the amount given in Table I.

The term "lot" applied to Table I means all of the plates of each group width and group weight.

30. When ordered to thickness, the thickness of each plate shall not vary 0.01 inch under that ordered.

The overweight of each lot in each shipment shall not exceed the amount given in Table II.

The term "lot" applied to Table II means all of the plates of each group width and group thickness.

Marking

Marking

31. The name or brand of the Manufacturer and the melt number shall be legibly stamped or rolled on all finished material, except that rivet and lattice bars and other small sections shall, when loaded for shipment, be properly separated and marked for identification. The identification marks shall be legibly stamped on the end of each pin and roller. The melt number shall be legibly marked, by stamping if practicable, on each test specimen.

TABLE I

PERMISSIBLE VARIATIONS OF PLATES ORDERED TO WEIGHT

ORDERED WEIGHT, LBS. PER SQ. FT.	PERMISSIBLE VARIATIONS IN AVERAGE WEIGHTS PER SQUARE FOOT OF PLATES FOR WIDTHS GIVEN. EXPRESSED IN PERCENTAGES OF ORDERED WEIGHTS.																		ORDERED WEIGHT, LBS. PER SQ. FT.
	Under 48 in.		48 to 60 in., excl.		60 to 72 in., excl.		72 to 84 in., excl.		84 to 96 in., excl.		96 to 108 in., excl.		108 to 120 in., excl.		120 to 132 in., excl.		132 in. or over.		
	Over	Under	Over	Under	Over	Under	Over	Under	Over	Under	Over	Under	Over	Under	Over	Under	Over	Under	
Under 5	5	3	5.5	3	6	3	7	3	...	...	...	...	...	...	...	...	...	...	Under 5
5 to 7.5 excl.	4.5	3	5	3	5.5	3	6	3	...	...	...	...	...	...	...	...	...	...	5 to 7.5 excl.
7.5 " 10 "	4	3	4.5	3	5	3	5.5	3	6	3	7	3	8	3	...	...	...	...	7.5 " 10 "
10 " 12.5 "	3.5	2.5	4	3	4.5	3	5	3	5.5	3	6	3	7	3	8	3	9	3	10 " 12.5 "
12.5 " 15 "	3	2.5	3.5	2.5	4	3	4.5	3	5	3	5.5	3	6	3	7	3	8	3	12.5 " 15 "
15 " 17.5 "	2.5	2.5	3	2.5	3.5	2.5	4	3	4.5	3	5	3	5.5	3	6	3	7	3	15 " 17.5 "
17.5 " 20 "	2.5	2	2.5	2.5	3	2.5	3.5	2.5	4	3	4.5	3	5	3	5.5	3	6	3	17.5 " 20 "
20 " 25 "	2	2	2.5	2	2.5	2.5	3	2.5	3.5	2.5	4	3	4.5	3	5	3	5.5	3	20 " 25 "
25 " 30 "	2	2	2	2	2.5	2	2.5	2.5	3	2.5	3.5	3	4	3	4.5	3	5	3	25 " 30 "
30 " 40 "	2	2	2	2	2	2	2.5	2	2.5	2.5	3	2.5	3.5	3	4	3	4.5	3	30 " 40 "
40 or over.	2	2	2	2	2	2	2	2	2.5	2	2.5	2.5	3	2.5	3.5	3	4	3	40 or over.

NOTE:—The weight per square foot of individual plates shall not vary from the ordered weight by more than one and one-third times the amount given in this table.

TABLE II

PERMISSIBLE OVERWEIGHTS OF PLATES ORDERED TO THICKNESS

ORDERED THICKNESS, INCHES	PERMISSIBLE EXCESS IN AVERAGE WEIGHTS PER SQUARE FOOT OF PLATES FOR WIDTHS GIVEN. EXPRESSED IN PERCENTAGES OF NOMINAL WEIGHT.									ORDERED THICKNESS, INCHES
	Under 48 in.	48 to 60 in., excl.	60 to 72 in., excl.	72 to 84 in., excl.	84 to 96 in., excl.	96 to 108 in., excl.	108 to 120 in., excl.	120 to 132 in., excl.	132 in. or over	
Under 1/8	9	10	12	14	....	....	....	....	....	Under 1/8
1/8 to 5/16 excl.	8	9	10	12	....	....	....	....	....	1/8 to 5/16 excl.
5/16 " 1/4 "	7	8	9	10	12	....	....	....	....	5/16 " 1/4 "
1/4 " 5/16 "	6	7	8	9	10	12	14	16	19	1/4 " 5/16 "
5/16 " 3/8 "	5	6	7	8	9	10	12	14	17	5/16 " 3/8 "
3/8 " 7/16 "	4.5	5	6	7	8	9	10	12	15	3/8 " 7/16 "
7/16 " 1/2 "	4	4.5	5	6	7	8	9	10	13	7/16 " 1/2 "
1/2 " 5/8 "	3.5	4	4.5	5	6	7	8	9	11	1/2 " 5/8 "
5/8 " 3/4 "	3	3.5	4	4.5	5	6	7	8	9	5/8 " 3/4 "
3/4 " 1 "	2.5	3	3.5	4	4.5	5	6	7	8	3/4 " 1 "
1 or over.	2.5	2.5	3	3.5	4	4.5	5	6	7	1 or over.

NOTE:—The weight of individual plates ordered to thickness shall not exceed the nominal weight by more than one and one-third times the amount given in this table.

APPENDIX VIII

SPECIFICATION FOR STRUCTURAL NICKEL STEEL

(In substantial agreement with A.S.T.M. Specification A 8-21)

MANUFACTURE

Process

1. The steel shall be made by the open-hearth process.

Discard

2. A sufficient discard shall be made from each ingot to secure freedom from injurious piping and undue segregation.

CHEMICAL PROPERTIES AND TESTS

Chemical Composition

3. The steel shall conform to the following requirements as to chemical composition:

	Structural Steel	Rivet Steel
Carbon	not over 0.45	not over 0.30 per cent
Manganese	" " 0.70	" " 0.60 " "
Phosphorus, Acid	" " 0.05	" " 0.04 " "
Phosphorus, Basic	" " 0.04	" " 0.03 " "
Sulphur	" " 0.05	" " 0.045 " "
Nickel	not under 3.25	not under 3.25 " "

Ladle Analyses

4. An analysis of each melt of steel shall be made by the Manufacturer to determine the percentages of the elements specified above. This analysis shall be made from a test ingot taken during the pouring of the melt. The chemical composition thus determined shall be reported to the Engineer and shall conform to the requirements specified above.

Check Analyses

5. Analyses may be made by the Engineer from finished material representing each melt. The chemical composition thus determined shall conform to the requirements specified above.

PHYSICAL PROPERTIES AND TESTS

Tension Tests

6. The material shall conform to the following requirements as to tensile properties except as modified hereinafter:

Properties Considered	Rivet Steel	Plates, Shapes and Bars	Eyebar Flats and Rollers, Unannealed	Eyebar Flats and Pins, Annealed
Tensile strength, lbs. per sq. inch	70 000–80 000	85 000–100 000	95 000–110 000	90 000–105 000
Yield point, min., lbs. per sq. inch	45 000	50 000	55 000	52 000
Elongation in 8 in., min., per cent	1 500 000 / Tens. str.	1 500 000 / Tens. str.	1 500 000 / Tens. str.	20
Elongation in 2 in., min., per cent	.....	.....	16	20
Reduction of area, min., per cent	40	25	25	35

7. Tests of annealed specimens of eyebar flats shall be made for information only.

8. In the case of pins and rollers, whether annealed or unannealed, the elongation shall be measured in 2 inches.

Yield Point

9. The yield point shall be determined by the drop of the beam of the testing machine.

Modifications in Elongation

10. For plates, shapes, and unannealed bars over 1 inch in thickness, a deduction of 0.25 from the percentage of elongation specified under "Tension Tests" above shall be made for each increase of 1/32 inch in thickness above 1 inch, to a minimum of 14 per cent.

Bend Tests

11. The test specimens for plates, shapes and bars shall bend cold through 180 degrees without cracking on the outside of the bent portion, as follows: For material 3/4 inch or under in thickness, around a pin the diameter of which is equal to the thickness of the specimen; and for material over 3/4 inch in thickness, around a pin the diameter of which is equal to twice the thickness of the specimen.

12. The test specimens for pins and rollers shall bend cold through 180 degrees around a one inch pin without cracking on the outside of the bent portion.

13. The test specimens for rivet steel shall bend cold through 180 degrees flat on themselves without cracking on the outside of the bent portion.

Drift Tests

14. Punched rivet holes pitched two diameters from a planed edge shall stand drifting until the diameter is enlarged 50 per cent., without cracking the metal.

Test Specimens

Test Specimens

15. Test specimens shall be prepared for testing from the material in its rolled or forged condition except when it is specified to be annealed; in which case the test specimens shall be prepared from the material as annealed for use, or from a short length of a full section similarly treated.

16. Test specimens shall be taken longitudinally, and, except as specified below, shall be of the full thickness or diameter of material as rolled.

17. Test specimens for plates, shapes, and flats may be machined to the form and dimensions shown in Fig. 1, or with both edges parallel; except that bend test specimens for eyebar flats may have three rolled sides.

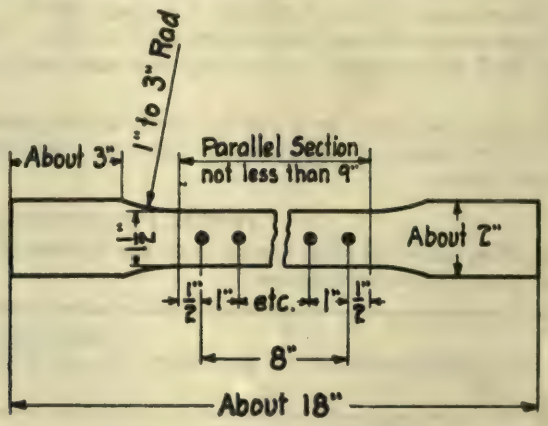


Fig. 1

18. Tension test specimens for plates and eyebar flats over 1½ inches in thickness, and bend test specimens for plates over 1½ inches in thickness, may be machined to a thickness or diameter of at least 3/4 inch for a length of at least 9 inches.

19. Test specimens for bars over 1½ inches in thickness or diameter may be machined to a thickness or diameter of at least 3/4 inch for a length of at least 9 inches; or tension test specimens may conform to the dimensons shown in Fig. 2, in which case the ends shall be of a form to fit the holders of the testing machine in such a way that the load shall be axial. Bend test specimens may be 1 x 1/2 inch in section.

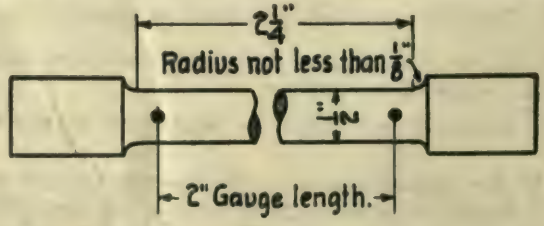


Fig. 2

Note—The gauge-length, parallel portions and fillets shall be as shown; but the ends may be of any form which will fit the holders of the testing machine.

20. Tension test specimens for pins and rollers shall conform to the dimensions shown in Fig. 2. In this case, the ends shall be of a form to fit the holders of the testing machine in such a way that the load shall be axial. Bend test specimens shall be 1 x 1/2 inch in section.

21. The tension test specimens shown in Fig. 2 and the 1 x 1/2 inch bend test specimen for pins and rollers shall be taken so that the axis is 1 inch from the surface; and for other bars over 1 1/2 inches in thickness or diameter, midway between the centre and surface.

22. The machined sides of rectangular bend test specimens may have the corners rounded to a radius not over 1/16 inch.

23. Test specimens for rivet bars which have been cold drawn shall be normalized before testing.

Number of Tests

24. One tension and one bend test shall be made from each melt; except that if material from one melt differs 3/8 inch or more in thickness, one tension and one bend test shall be made from both the thickest and the thinnest material rolled.

25. If any test specimen shows defective machining or develops flaws, it may be discarded and another specimen substituted.

Retests

26. If the percentage of elongation of any tension test specimen is less than that specified above under "Tension Tests" and any part of the fracture is more than 3/4 inch from the centre of the gauge length of a 2 inch specimen or is outside the middle third of the gauge length of an 8 inch specimen, as indicated by scribe-scratches marked on the specimen before testing, a retest shall be allowed.

Character of Fracture

27. All broken tension test specimens shall show either a silky or a very fine granular fracture, of uniform colour, and free from coarse crystals.

Finish

Defects

28. Finished rolled material shall be free from cracks, flaws, injurious seams, blisters, ragged and imperfect edges, and other surface defects. It shall have a smooth finish, and shall be straightened at the mill before shipment.

Permissible Variations In Weight And Thickness

Permissible Variations

29. The cross-section or weight of each piece of steel shall not vary more than 2.5 per cent. from that specified; except in the case of sheared plates, which shall be covered by the following permissible variations. One cubic inch of rolled steel is assumed to weigh 0.2833 lb.

30. When ordered to weight per square foot, the weight of each lot in each shipment shall not vary from the weight ordered more than the amount given in Table I.

The term "lot" applied to Table I means all of the plates of each group width and group weight.

31. When ordered to thickness, the thickness of each plate shall not vary more than 0.01 inch under that ordered.

The overweight of each lot in each shipment shall not exceed the amount given in Table II.

The term "lot" applied to Table II means all of the plates of each group width and group thickness.

Marking

Marking

32. The name or brand of the Manufacturer and the melt number shall be legibly stamped or rolled on all finished material, except that rivet and lattice bars and other small sections shall, when loaded for shipment, be properly separated and marked for identification. The identification marks shall be legibly stamped on the end of each pin and roller. The melt number shall be legibly marked, by stamping if practicable, on each test specimen.

TABLE I

PERMISSIBLE VARIATIONS OF PLATES ORDERED TO WEIGHT

ORDERED WEIGHT, LBS. PER SQ. FT.	PERMISSIBLE VARIATIONS IN AVERAGE WEIGHTS PER SQUARE FOOT OF PLATES FOR WIDTHS GIVEN. EXPRESSED IN PERCENTAGES OF ORDERED WEIGHTS.																		ORDERED WEIGHT, LBS. PER SQ. FT.
	Under 48 in.		48 to 60 in., excl.		60 to 72 in., excl.		72 to 84 in., excl.		84 to 96 in., excl.		96 to 108 in., excl.		108 to 120 in., excl.		120 to 132 in., excl.		132 in. or over.		
	Over	Under	Over	Under	Over	Under	Over	Under	Over	Under	Over	Under	Over	Under	Over	Under	Over	Under	
Under 5	5	3	5.5	3	6	3	7	3	...	...	...	...	...	...	...	...	...	...	Under 5
5 to 7.5 excl.	4.5	3	5	3	5.5	3	6	3	...	...	...	...	...	...	...	...	...	...	5 to 7.5 excl.
7.5 " 10 "	4	3	4.5	3	5	3	5.5	3	6	3	7	3	8	3	...	...	...	...	7.5 " 10 "
10 " 12.5 "	3.5	2.5	4	3	4.5	3	5	3	5.5	3	6	3	7	3	8	3	9	3	10 " 12.5 "
12.5 " 15 "	3	2.5	3.5	2.5	4	3	4.5	3	5	3	5.5	3	6	3	7	3	8	3	12.5 " 15 "
15 " 17.5 "	2.5	2.5	3	2.5	3.5	2.5	4	3	4.5	3	5	3	5.5	3	6	3	7	3	15 " 17.5 "
17.5 " 20 "	2.5	2	2.5	2.5	3	2.5	3.5	2.5	4	3	4.5	3	5	3	5.5	3	6	3	17.5 " 20 "
20 " 25 "	2	2	2.5	2	2.5	2.5	3	2.5	3.5	2.5	4	3	4.5	3	5	3	5.5	3	20 " 25 "
25 " 30 "	2	2	2	2	2.5	2	2.5	2.5	3	2.5	3.5	3	4	3	4.5	3	5	3	25 " 30 "
30 " 40 "	2	2	2	2	2	2	2.5	2	2.5	2.5	3	2.5	3.5	3	4	3	4.5	3	30 " 40 "
40 or over.	2	2	2	2	2	2	2	2	2.5	2	2.5	2.5	3	2.5	3.5	3	4	3	40 or over.

NOTE:—The weight per square foot of individual plates shall not vary from the ordered weight by more than one and one-third times the amount given in this table.

TABLE II

PERMISSIBLE OVERWEIGHTS OF PLATES ORDERED TO THICKNESS

ORDERED THICKNESS, INCHES	PERMISSIBLE EXCESS IN AVERAGE WEIGHTS PER SQUARE FOOT OF PLATES FOR WIDTHS GIVEN. EXPRESSED IN PERCENTAGES OF NOMINAL WEIGHT.									ORDERED THICKNESS, INCHES
	Under 48 in.	48 to 60 in., excl.	60 to 72 in., excl.	72 to 84 in., excl.	84 to 96 in., excl.	96 to 108 in., excl.	108 to 120 in., excl.	120 to 132 in., excl.	132 in. or over	
Under 1/8	9	10	12	14	....	....	....	....	....	Under 1/8
1/8 to 5/32 excl.	8	9	10	12	....	....	....	....	....	1/8 to 5/32 excl.
5/32 " 1/4 "	7	8	9	10	12	....	....	....	....	5/32 " 1/4 "
1/4 " 5/16 "	6	7	8	9	10	12	14	16	19	1/4 " 5/16 "
5/16 " 3/8 "	5	6	7	8	9	10	12	14	17	5/16 " 3/8 "
3/8 " 7/16 "	4.5	5	6	7	8	9	10	12	15	3/8 " 7/16 "
7/16 " 1/2 "	4	4.5	5	6	7	8	9	10	13	7/16 " 1/2 "
1/2 " 5/8 "	3.5	4	4.5	5	6	7	8	9	11	1/2 " 5/8 "
5/8 " 3/4 "	3	3.5	4	4.5	5	6	7	8	9	5/8 " 3/4 "
3/4 " 1 "	2.5	3	3.5	4	4.5	5	6	7	8	3/4 " 1 "
1 or over.	2.5	2.5	3	3.5	4	4.5	5	6	7	1 or over.

NOTE:—The weight of individual plates ordered to thickness shall not exceed the nominal weight by more than one and one-third times the amount given in this table.

APPENDIX IX

SPECIFICATION FOR CAST STEEL

(In substantial agreement with A.S.T.M. Specification A 27-21)

MANUFACTURE

Process

1. The steel shall be made by one or more of the following processes: open-hearth, electric furnace, side-blow converter, or crucible.

Heat Treatment

2. Castings shall be properly annealed, the treatment depending upon the design and chemical composition of the castings. A group thus annealed will be known as an "annealing charge".

CHEMICAL PROPERTIES AND TESTS

Chemical Composition

3. The castings shall conform to the following requirements as to chemical composition:

Phosphorus	Acid	not over 0.06 per cent.
	Basic	" " 0.05 " "
Sulphur		" " 0.06 " "

Ladle Analyses

4. An analysis of each melt of steel shall be made by the Manufacturer to determine the percentage of carbon, manganese, phosphorus and sulphur. This analysis shall be made from drillings taken at least 1/4 inch beneath the surface of a test ingot obtained during the pouring of the melt. The chemical composition thus determined shall be reported to the Engineer and shall conform to the requirements specified above.

Check Analyses

5. Analyses of castings may be made by the Engineer from a broken tension or bend test specimen. The phosphorus and sulphur content thus determined shall not exceed that specified above, by more than 20 per cent. Drillings for analyses shall be taken not less than 1/4 inch beneath the surface.

PHYSICAL PROPERTIES AND TESTS

Tension Tests

6. The castings shall conform to the following minimum requirements as to tensile properties:

Tensile Strength	lbs. per sq. inch 60 000
Yield point	lbs. per sq. inch 0.45 tens. str.
Elongation in 2 inches	per cent. 22.
Reduction of areas	per cent. 30.

Yield Point

7. The yield point shall be determined by the drop of the beam of the testing machine.

Bend Tests

8. The test specimens shall bend cold through 120 degrees around a one-inch pin, without cracking on the outside of the bent portion.

Test Specimens

9. Sufficient test bars, from which the Engineer may select the test specimens required for the tests specified below under "Number of Tests", shall be attached to castings weighing 500 lbs. or over, when the design of the castings will permit. If the castings weigh less than 500 lbs., or are of such a design that test bars cannot be attached, two test bars shall be cast to represent each melt.

10. Test bars shall be annealed with the castings they represent.

11. The Contractor and Engineer shall agree whether test bars can be attached to castings, on the location of the bars on the castings, on the castings to which bars are to be attached, and on the method of casting unattached bars.

12. Tension test specimens shall conform to the dimensions shown in Fig. 1. The ends shall be of a form to fit the holders of the testing machine in such a way that the load shall be axial.

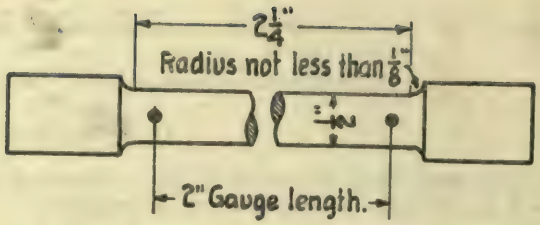


Fig. I

Note—The gauge-length, parallel portions and fillets shall be as shown, but the ends may be of any form which will fit the holders of the testing machine.

13. Bend test specimens shall be machined to 1 x 1/2 inch in section, with corners rounded to a radius not greater than 1/16 inch.

Number of Tests

14. One tension and one bend test shall be made from each annealing charge. If more than one melt is represented in an annealing charge, one tension and one bend test shall be made from each melt.

15. If any test specimen shows defective machining or develops flaws, it may be discarded; in which case the Contractor and the Engineer shall agree upon the selection of another specimen in its stead.

Retests

16. If the percentage of elongation of any tension test specimen is less than that specified above, under "Tension Tests", and any part of the fracture is more than 3/4 inch from the centre of the gauge length, as indicated by scribe-scratches on the specimen before testing, a retest shall be allowed.

17. If the results of the physical tests of any test lot do not conform to the requirements specified, the Manufacturer may re-anneal such lot not more than twice, and retests shall be made as specified above, under "Tension Tests" and "Bend Tests."

Workmanship And Finish

Finish

18. The castings shall conform substantially to the sizes and shapes of the patterns, shall be free from excessive shrinkage, and shall be made in a workmanlike manner.

Defects

19. The castings shall be free from injurious defects. Minor defects which do not impair the strength of the castings may, with the approval of the Engineer, be welded by an approved process. The defects shall first be cleaned out to solid metal; and, after welding, the castings shall be annealed, if required by the Engineer.

Rejection

20. Castings which show injurious defects after machining will be rejected, notwithstanding any previous acceptance at the Manufacturer's works.

APPENDIX X

SPECIFICATION FOR CAST IRON

(In substantial agreement with A.S.T.M. Specification A 48-18 and A.R.E.A. Bridge Material Specification, 1920)

MANUFACTURE

Process

1. The castings shall be of tough grey iron and shall be made by the cupola process.

Material Covered

2. This Specification covers three classes of grey iron castings, as follows:
(*a*) Light Castings, those having any section less than 1/2 inch in thickness.
(*b*) Heavy Castings, those in which no section is less than 2 inches in thickness.
(*c*) Medium Castings, those not included in either of the above two classes.

CHEMICAL PROPERTIES AND TESTS

Chemical Composition

3. Drillings taken from the fractured end of the transverse test bars shall conform to the following requirements as to sulphur:

Light castings	not over 0.10 per cent.
Medium castings	" " 0.10 " "
Heavy castings	" " 0.12 " "

4. One sulphur determination shall be made for each set of test bars cast.

PHYSICAL PROPERTIES AND TESTS

Transverse Tests

5. The transverse test bars shall be prepared as specified under "Test Bars" below, and shall be placed horizontally upon supports 12 inches apart and tested under a centrally applied load. The load on the test bar at rupture and the deflection at rupture shall conform to the following minimum requirements:

	Class of Casting		
	Light	Medium	Heavy
Load at centre, lbs	2 500	2 900	3 300
Deflection at centre, inch	0.10	0.10	.010

6. The rate of application of the load shall be such that a central deflection of 0.10 inch is produced from 20 to 40 seconds.

Number of Tests

7. Two sets of two test bars each shall be cast from each melt in thoroughly dried green sand moulds (prepared as described below under "Test Bars") one set from the first iron poured and the other set from the last iron poured. Where the melt exceeds 20 tons, an additional set of two bars shall be cast from each additional 20 tons or fraction thereof.

8. A transverse test of each bar cast shall be made.

Requirements

9. One test bar of each set (or pair of bars) cast shall conform to the requirements specified above under "Transverse Tests" and under "Chemical Composition", otherwise the castings represented by such bars shall be rejected.

Test Bars

10. The form and dimensions of the mould for the test bars shall be in accordance with Fig. I. The bottom of the bar shall be 1/16 inch smaller in diameter than the top, to allow for draft and for the strain of pouring. The pattern shall not be rapped before withdrawing. The flask shall be rammed up with green moulding sand, a little damper than usual, well mixed and put through a No. 8 sieve, with a mixture of 1 to 12 bituminous facing. The mould shall be rammed evenly and fairly hard, thoroughly dried, and not cast until it is cold. The test bar shall not be removed from the mould until cold enough to be handled. It shall not be rumbled or otherwise treated, being simply brushed off before testing.

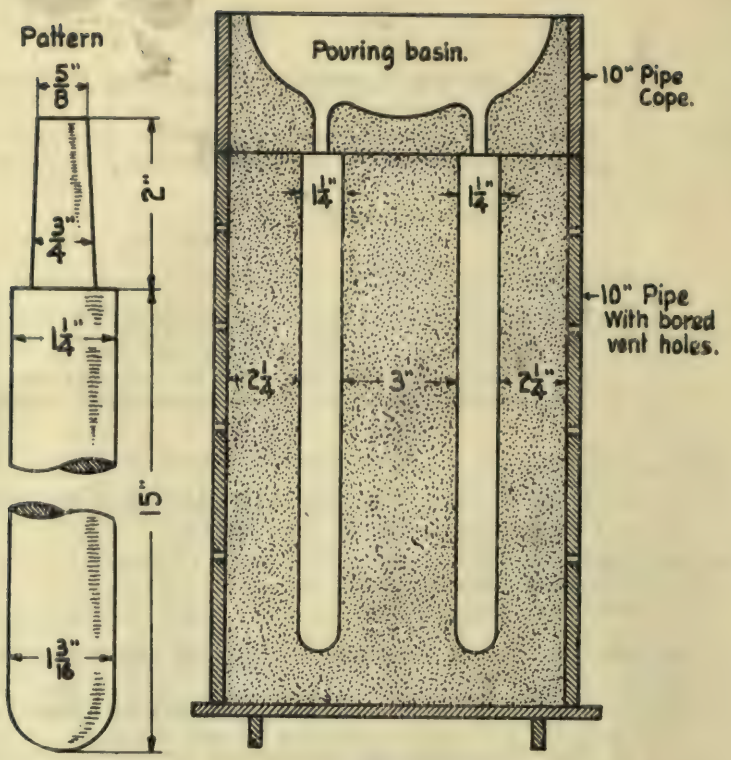


Fig. I

Tension Tests

11A. Tension tests will be made only when and as specified by the Engineer and at the expense of the Railway Company.

Workmanship And Finish

Finish

12. The castings shall be true to pattern, free from excessive shrinkage and shall be made in a workmanlike manner.

Defects

13. They shall be free from cracks, cold shuts, blow holes, flaws, and other injurious defects.

Rejection

14. Castings which show injurious defects after machining will be rejected, notwithstanding any previous acceptance at the Manufacturer's works.

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